A Pattern-Based Approach to Changing Software Requirements in Brown-Field Business Contexts

Thesis

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John Brier Dipl. Arch (Leeds) MBA

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Computing

Department of Computing

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Abstract

In organisations, competitive advantage is increasingly reliant on the alignment of socio-technical systems with business processes. 'Socio-technical' refers to the complex systems of people, tasks and technology. Supporting this alignment is exacerbated by the speed of technological change and its relationship with organisation growth. This complexity is further aggravated in a number of ways. Organisations and/or parts of organisations are structured differently and have different approaches to change. These differences impact on their responsiveness to change, their use of technology, and its relationship to business processes.
In requirements engineering, a lack of understanding of the organisational context in which change takes place has been a problem over the last decade. Eliciting requirements is complex, with requirements changing constantly. Delivered change is affected by further changing needs, as stakeholders identify new ways of using IT. Changing requirements can lead to mismatches between tasks, technology and people. Relations and their alignment can be compromised.
We contribute to understanding this complex domain by presenting an approach which engages with stakeholders/users in the early stages of the requirements elicitation process. The two expressions of the approach are derived from the literature and 19 real-world studies. They are referred to as Conceptual Framework and Change Frame. Both support a problem-centred focus on context analysis when reasoning about changing technology in business processes. The framework provides structures, techniques, notation and terminology. These represent, describe, and analyse the context in which change takes place, in the present and over time. The Change Frame combines an extension of the framework with an organisation pattern. It facilitates representing, describing and analysing change, across the strategic/operation area of an organisation. A known pattern of solution is provided, for the recurring change problem of representing an organisation-wide change in different organisation locations. Chapter 4 shows the conceptual framework in the context of a real-world study, and chapter 6 uses a real-world use/case scenario to illustrate the change frame. Both chapters show support for understanding change, through client/customer and stakeholder/users reasoning about the implications of change.

Author's Declaration

Some of the material in this thesis has been previously published in the following papers. They are available at: http://www.mcs.open.ac.uk/People/J.Brier

Refereed Publications:

2004 - Brier, J., Rapanotti, L., and Hall, J. *Problem Frames for Socio-Technical Systems: predictability and change.* - The 1st International Workshop on Advances and Applications of Problem Frames, Edinburgh: (ICSE'04).

2005 - J. Brier, L. Rapanotti, J. Hall. *Towards capturing Change in Socio-Technical Systems Requirements.* - The 11th International Workshop on Requirements Engineering Porto, Portugal.

2006 - Brier, J., Rapanotti, L., and Hall, J. *Problem-based Analysis of Organisational Change: a real World Example.* The 2nd International Workshop on Advances and Applications of Problem Frames, Shanghai, China (ICSE'06).

Technical Reports:

2005/01 - Brier, J., Rapanotti, L., and Hall, J., *Capturing Change in Socio-technical Systems with Problem Frames - a technical report.* 4/1/2005, Department of Computing, The Open University, Milton Keynes - (ISSN 1744-1986).

2006/08 - Brier, J., Rapanotti, L., and Hall, J., *Capturing Change descriptions as Patterns in an Organisations changing Socio-technical system - a technical report* – 17/11/2006, Department of Computing, The Open University - (ISSN 1744-1986)

All of the work presented in this thesis describes original contributions by the author except as noted.

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Table of Contents

Figures & Tables

Chapter 1. The thesis context

The complexity of change in real-world organisations provides a challenging task for software systems in general and requirements engineering (RE) in particular. In RE, green-field developments have been the focus of most of the guidance produced, with little guidance being provided for what is referred to as brown-field developments (RESG, 2010). 'Green-field developments' refer to a wholly-new product or system, and 'brown-field developments' refer to changes to existing systems or software, developed in the context of existing systems or software. A recent call for papers from the Business Process Modelling Development Support conference confirms a continuing need to understand the organisation context when changing requirements (BPMDS, 2010). The conference highlights the need for alignments with context, maintaining coherence when business change takes place, and the importance of context aware and re-usable artefacts.

In RE, a lack of understanding of changing requirements has been a problem for a number of years. Nuseibeh and Easterbrook (2001) identified managing change as a fundamental need in software development. In 2002, a mismatch was identified between the technical and the organisation environment (Castro *et al*., 2002), and in 2005, attention was drawn to the need for explicit evolution requirement descriptions referring to computer science research that:

> *"…analyse the reciprocal evolution of systems or software and other entities such as organisations, business processes or environment…"* (Etien and Salinesi, 2005 - p. 1)

When scoping the context in which change takes place, a continuing problem has been deciding if changing requirements should be considered as a single step, or considered flexibly over time. For instance, in 1992 it was stated that:

> *"...there is now ample evidence from field studies that this view of a static set of requirements to be captured and classified is inappropriate...changing requirements rather than stable ones are the norm in systems development…"* '(Harker *et al*., 1992 - p. 266)

A later statement identified the need to understand the organisation context of requirements changing over time:

> *"…little attention has been given to systematically understanding and modelling the relationships between business goals and system qualities...in particular, modelling must encompass changes to business goals over time and their effects upon a system's architecture…"* (Gross and Yu, 2001 – p. 1)

In 2005, a focus on changing requirements supported a continuous and systematic approach to evolution expressed as moving from a 'before-the-change' to an 'after-the-change' situation (Etien and Salinesi, 2005). More recently, system evolution was referred to as a fluid activity. It was noted that the design of an information system should consider evolution as an inherent property of the system.

> *"…The evolution of an information system should be a continuous process rather than a single step, and it should be inherently supported by the system itself, and the design should consider evolution as an inherent property of the system…"* (CAiSE, 2010 - p. 1).

1.1 Research aim

The RE literature suggests that advances in approaches to brown-field development occurs through the resolution of RE problems. These are identified when developing existing systems and software. Resolving these problems provides future guidance when similar problems occur. However, re-using guidance is limited as organisations are different, and so are the contexts in which change occurs. The subject of change can be an organisation, a part of an organisation, organisation subsidiaries, and different organisation sectors. Even when the scope of alternative contexts is similar, there are still variables that complicate mapping change from one situation to another. A similarity of scope might exist between two departments in the same organisation, but they may have different approaches to their operations. There could be different responses to growth, alternative approaches to change (e.g., in the present or over time), and/or complexity arising from the speed with which new technology is adopted.

In summary, when requirements change in organisations, it is a response to change in the brown-field context in which they reside. Organisations are complex. They incorporate variables that exacerbate the scoping and description of the context in which change takes place, identifying change problems, and reasoning about how change should be realised. These variables limit the extent to which context descriptions between organisations are similar, and consequently they limit the mapping of change descriptions between locations. Recent literature shows there has been little guidance for supporting brown-field developments, identifies a need for context-aware and re-usable artefacts, along with support for analysing the context where change takes place.

In response to problems of changing requirements in an organisation's brown-field situation, this research aims to provide guidance that facilitates understanding the context in which change takes place. This is summarised in the following research question:

In an organisation brown-field context, how can changing requirements be represented, in order to facilitate identifying problems, and reason about how change should be realised?

1.2 Research methodology and thesis outline

The research presented here has generally been analytical, based on evidence gathered and evaluated following a review of the literature and data from 19 real-world studies. The structure of the approach is summarised in the following chapter descriptions. Throughout the remainder of the thesis, we use the **'bold'** designation for significant words and/or important parts of the text. *Italics* are used for quotations, and to express some diagram notations in the text.

Chapter 2 reviews literature related to problems of changing technology in organisations. Timelines position the onset of initiatives and identify problems which were a focus for consideration. Conclusions identify the thesis objective as: facilitating an understanding of change, through client/customer and stakeholder/users experiencing a process of change.

Chapter 3 presents the conceptual framework. It has been derived from the literature and from an analysis of 19 real-world studies reported in the literature, and it provides structures, techniques, notation and terminology for reasoning about changing requirements. A real-world study in chapter 4 illustrates the approach.

Chapter 5 introduces the change frame. This combines an organisation pattern with the conceptual framework. It facilitates re-using change context descriptions in recurring change situations. The organisation pattern is again derived from the literature and from an analysis of the 19 real-world studies. Chapter 6 illustrates the change frame by reference to a real world use case/scenario which represents a typical University .

Chapter 7 discusses the extent to which the research question has been addressed, concludes the thesis, and considers future work. The appendices include:

Appendix 1 – Glossary A – Requirements terminology,

Appendix 2 – Glossary B – Organisation terminology,

Appendix 3 – List of case studies, and

Appendix 4 – Supporting information.

Chapter 2. Literature Review

2.1 Introduction

Within the context of changing requirements in organisations, this chapter discusses existing RE and organisational literature. The increasing complexity of changing technology is characterised, and related initiatives of the time are described. Identifying structures, techniques, notations and terminology informs future approaches to brown-field developments when changing technology. Timelines are incorporated to aide discovering recurring themes, and to facilitate comparisons between RE and organisational development literatures.

Chapter 1 concludes that whilst guidance has been provided for initiating RE green-field projects, little has been provided for understanding the context when changing completed green-field projects. In RE terms, a green-field project represents new development. When completed RE green-field developments are changed, they are referred to as RE brown-field contexts. Referring to the legacy of green-field approaches (e.g., structures, techniques, notation, terminology etc.) supports the grounding of brown-field transformations in the environment in which technology is used. Grounding requirements in the environment in which they are used is supported by the literature:

"…all descriptions involved in requirements engineering should be descriptions of the environment….with the terminology used grounded in the reality of the environment for which a machine is to be built…" (Zave and Jackson, 1997 - p. 2)

The remainder of this chapter considers RE approaches that have an impact on changing contexts in both organisations and requirements engineering. Existing practice and techniques are discussed, and strengths and weaknesses are identified which are relevant to informing the context of changing requirements. Following the introduction, the chapter discusses: reacting to changing organisations; reacting to changing requirements; and conclusions.

2.2 Reacting to changing organisations

RE emerged as a field of study in its own right in the early 1990's (Nuseibeh and Easterbrook, 2000 - p. 3). This is in contrast to organisation development, a field which grew its roots in the early part of the 20th century, as represented by Taylor's formal approach to applying scientific principles of management (Taylor, 1911). Forces for change have traditionally been identified as either external or internal to an organisation's environment. External change is rooted in the political, economic, social or technology (PEST) environments (Porter, 1985). These are usually from two separate sources. First, from sources not directly involved in the industry sector (e.g.: government departments, public bodies, etc.). Second, from change originating in the resource areas within an organisation's industry sector (Tavistock Institute, 1966), such as adopting different classical and/or human relationship theories of management over time (Cole, 1988), technology change, or changes in working practices (Spender, 1996).

Over time, understanding the changing organisation context has become more complex. Implementing change is being exacerbated by the speed of technological change and its relationship to organisational growth. A consequence of the growing influence of technology

has been the introduction of structures, techniques, notations and terminology, in order to support change and to mitigate problems when change takes place. Since 1980 there have been different levels of technology take-up by organisations, and the development of different approaches to change. We discuss change around the notion of organisations evolving from a position of containing change, to embracing change, and to harnessing change. Containing and embracing change refer to different but progressive reactive approaches to change. The reactive approach is a response to a deterministic requirement to change. Embracing change reflects a more adaptable approach when reacting to change than that of contained change. Harnessing change represents a pro-active approach to change. This is a volitional action which can start, with a suggestion for change. For instance, a change suggested by an employee or group within an organisation. The timeline by which this is presented gives an historical perspective on problems of change, the consequent causes of complexity and uncertainty when considering change, and the development of representations used when describing change.

Whilst technology was a focus for change from 1990, its incorporation in organisation approaches to change had appeared earlier.

2.2.1 1960 to 1980 contexts for change

In this period, the Tavistock Institute coined the phrase that identified organisations as 'open socio-technical systems' (Tavistock Institute, 1966). Also Burns and Stalker indicated that the effectiveness of organisations in changing conditions reflected an organisation's different structural and/or design approaches (Burns and Stalker, 1966). The pragmatic theory which emerged suggested that no one existing theory could guarantee the effectiveness of an organisation. From this evolved the general view that the structure and/or design of an organisation should fit certain variable characteristics. These variable characteristics provide a focus for coordinating and controlling change in organisations. They relate to both external and

internal environments in which organisations operate. The following generic variables and consequent terminology were introduced;

- the environment in which an organisation operates (Duncan, 1972, Emery, 1969),
- the nature of interdependencies that exist within an organisation (Aiken and Hage, 1968, Milman *et al*., 1991, Thompson, 1967),
- the technologies used by an organisation (Tushman and Nadler, 1978).

Tushman and Nadler, focussing on information processing systems, stated that:

> *"… a critical task of the organisation was to facilitate the collection, gathering and processing of information about how different components in the organisation are functioning…"* (Tushman and Nadler.D. 1978 - p. 614)

In short, organisations must develop information processing mechanisms capable of dealing with external and internal sources of uncertainty, in order to:

> *"… create the most appropriate configuration system to facilitate the effective collection, processing and distribution of information…"* (Ibid., - p. 614)

Review

Approaches to change in this period were generally reactive and concentrated on minimising internal change. The earlier introduction of fit and consistency of variables (1960 to 1980) highlighted a focus on *problems* when coordinating and controlling change. Information processing models achieved consistency by introducing the notion of 'fit' between environment, interdependencies and technology. This reflected the use of patterns to represent and understand change. These three variables, used as a pattern, standardised a high-level approach to these concepts when considering change and facilitated the consideration of relationships between

them. Organisations looked to balance information processing capacities, with information processing requirements. We refer to this approach as contained change.

Whilst the notion of fit between variables provided a basis for considering change, their expression was generally related to overarching approaches (i.e., expressed as a high level of generality). There was a lack of specificity. This led to further, more detailed characterisations of change in the 1980's.

2.2.2 1980-1990 contexts for change

In 1981, systems theory drew attention to identifying relationships at a more detailed level when change takes place. Checkland (1981) introduced an approach that states that changes in one system element result in changes elsewhere. Additionally, in 1985, the ability of change to achieve competitiveness was seen to depend on the extent to which an organisation's characteristics could fit changing marketplace conditions. This resulted in more detailed descriptions of size, culture, resource, utilisation, effectiveness, efficiency and flexibility. There was a consequent impact on descriptions of change. Also, detailed categorisations of organisation contexts were introduced. These were referred to as:

- *intra-organisational* - internal to the organisation, for example, including employees, subsidiaries, etc.;
- *inter-organisational* – between organisations, for example, working with suppliers, subcontractors, etc.;
- *extra-organisational* – including individuals outside the organisation, but still having relationships with the organization, for example, customers, consultants, competitors, etc., (Porter, 1985).

These categories show that parts of organisations and their communities have different characteristics. When organisation-wide change takes place, the intra-, inter-, or extra-

organisation contexts can be affected by and represent that change differently. Change is interpreted according to the needs of its context.

These different characteristics were further informed by Cole in his book on organisation development and control (Cole, 1988). Control relates to the power of directing or regulating causal phenomena. Characteristics of control include whether a domain is *static* (without change) or *dynamic* (changing). Hence, descriptions of organisational contexts could be further defined by identifying them as dynamic or static.

Review

Whilst in the period 1980 - 1990 there was more detailed guidance for considering change than previously, the guidance was still generally for reactive situations. Change was driven mainly by the external environment, with an emphasis on minimising internal change. For instance, change in government legislation might provoke a reaction whose goal was to limit the legislation's impact on business processes. Subsequently there were prescriptive approaches referred to as classical theories of management (Johnson and Scholes, 1989), which encouraged more proactive planning activity by organisations. Structures and activities were formalised. The pattern of the three related contexts (i.e., intra-, inter- and extra-organisation) suggested a more structured approach when interpreting change across the organisation. For instance, an external driver such as a legislative change could affect these different parts of an organisation in different ways. Also, proactive planning activity supported predicting organisational behaviour, and encouraged adaptation to change. We refer to this proactive approach as '*embracing'* change. As organisations are at different stages of growth and have different attitudes to change this period reflects a mix of contained and embracing approaches to change. Whilst characterising change, these approaches also help to make the developing complexity of changing organisations visible.

2.2.3 1990 - 1999 contexts for change

In this period, the increasing development of technology became a driving force in organisation approaches to competitive advantage (Spender, 1996). There was a consequent impact on approaches to change. Traditional reactive approaches to change were being replaced by more proactive approaches. There was a proliferation in the literature of suggestions, guidance and support for change.

At the start of the period, Cole's notion of dynamic and static environments was extended. Where previous approaches had concentrated on implementing controls in organisations, the idea of adapting to change implied a need to be flexible. Stacey's reference to control and flexibility suggests that parts of organisations should be categorised in terms of flexibility as well as control (Stacey, 1990). In the organisation context, Stacey associates 'static' with the notion of a domain that is resistant to change, with the consequence that external change cannot impact on existing control mechanisms. He identifies three categories: open change, closed change and contained change. Open change describes a context which is dynamic and provides maximum flexibility with minimum control. Closed change describes a context which is static and provides a minimum of flexibility with maximum control. Contained change describes a balance of control and flexibility. These categories indicate the extent to which organisation control mechanisms provide flexibility for the activities being carried out. They highlight relationships between control and flexibility.

Other influences in the discourse of change during this period included a focus on acquiring new knowledge, and the importance of context. This search for new knowledge sources included expertise and its relationship to social contexts. In 1994, the 'context of application' referred to adapting a contextual approach to reasoning about change. In response to the identification of outputs from a reasoning process about problems, experts involved in the exercise would be replaced when their function, and/or contribution, was perceived to be exhausted. (Gibbons *et al*., 1994). This contextual approach is flexible, with outputs evaluated as they occur to ensure the social context in which they are being identified remains effective.

Later, more detailed approaches to knowledge and context extended the understanding of context. Different notions of expert and context were expressed. A plumber can be regarded as an expert on the basis of what he has in his mind, or on the basis of the relationship between what he has in his mind and the context of the community of practice in which he operates (Hopman *et al*., 1997- p. 552).

> *"...when studying expertise, the minimum unit of analysis is the 'expert in context'...this view of expertise suggests that knowledge engineers should focus on modelling the functional (but fallible) interactions between the expert and his social/physical context...the expert's constructions or procedures (i.e., mental models), may be more or less valid in a scientific sense, but do need to be functional in helping the constituencies manage their uncertainties"* (Feltovich *et al*., 1997 - p. 553)

Clancy also associates context with the expertise of individuals and the term 'socially-constructed knowledge':

.

> *"...an individual's capacity to engage in an activity may be characterized as knowledge. Thus 'knowledge is socially constructed' means first, that 'knowledge develops and has value within activity', and second, 'activities are socially constructed'...*" (Clancy 1997 - p. 270)

Clancy's consideration of problem solving highlights uncertainties of context. A distinction is drawn between problems in practice, and the formal problem solving of professionalism. The relationship between the theoretical and the practical is expressed as follows,

> *"...the scientific view of problem solving is that one starts with certain data, a goal, and certain theories about how goals and facts are related. But in practice the problem is*

often which kinds of facts are relevant and how to justify action, within a matrix of conflicting regulations and competing judgements..." (Clancy 1997 - p. 270)

Earlier reference to knowledge sources referred to learning-by-doing, experiential learning, and sense-making. Learning-by-doing refers to improvement through repeating similar types of action. It relates to experiential learning, the making of meaning from direct experience, and provides one early subject for reflection and its proactive approach to change. Reflection-in-action (analysing situations in the present) and reflection-on-action (analysing situations after experience) are subjects of the book, The Reflective Practitioner (Schon D., 1983). Analysing after experience can contribute to dealing with a repeat situation differently (Kolb and Fry 1975). Later contributions to characterising change referred to sense making. Sense making is the process by which meaning is given to experience.

"...The basic idea of sense-making is that reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs…" (Weick, 1993 - p. 635)

In this period there was a focus on relationships between strategic, manager, and operation activities when change takes place. Strategic ideas referred to both external and internal contexts. External contexts concern ideas that incorporate competitive advantage in the marketplace. Internal contexts are concerned with managing an organisation's knowledge.

Knowledge management, introduced as a business approach, had a focus on the acquisition and managing of an organisation's knowledge. Harnessing knowledge was seen to provide competitive advantage (Grant, 1996). In considering change, (Peters, 1998) inaugurated a genre of books on managing change. Change was seen as ubiquitous, demanding new ways of representing and characterising change. Earlier, organisations had conventionally managed their explicit knowledge (i.e., knowledge made available by organisations). Now, they were managing the identification and use of implicit knowledge (i.e., knowledge previously

unidentified). This reflected the search for unique knowledge sources for competitive advantage (Nonaka and Takeuchi, 1995). Subsequently, there was a move toward flatter and nimbler organisation structures (Peters, 1998). The traditional hierarchical approach to management was being complemented or replaced by management structures that reduced the time required to implement an idea. The beauracracy in hierarchical structures aggravated the speed with which decisions were taken.

During this period there was an increasing number of ways of expressing change, exacerbating the complexity of change and obstructing understanding. In response, knowledge representations were introduced, as in the following categorisation (Amidon and Skyrme, 1997):

- know what – the basic sense of knowing;
- know how –knowledge of how things get done;
- know who – knowing who does the doing;
- know when – a sense of timing;
- know where – where things are carried out;
- know why – the wider context and the vision.

The focus on knowledge management also characterised existing organisation relationships differently. The emphasis on strategy highlighted relationships between strategic intent and its transformation into operation reality. This led to a body of literature reinforcing the manager level, as mediating change between the strategic and operation levels of an organisation (Senge et al., 1999). Transforming strategic knowledge into operation knowledge expresses an organisation-wide change differently, when implemented in different situations (i.e., as in the previous intra-, inter- and extra-organisation contexts). Whilst the representation, characterisation, and description of change can be different in different locations, there is similarity based on their inter-relationship. For example, the CEO level (strategic) may decide to invest in additional computing at the operation level of the organisation, but request the

Manager to determine how and where this can be most effectively deployed. We refer to these different levels as strategic intent, manager transformation, and operation reality.

During this period, there was a developing use of frameworks and patterns. One approach links an understanding of culture to the organisation environment. It considers relationships between culture, ambiguity and change when innovating (Martin and Meyerson, 1990). Three interactive perspectives are viewed sequentially and repeatedly. They are referred to as an integrating perspective, a differentiating perspective, and an ambiguity perspective and reflect patterns that simplify complexity through the identification of relationships. For instance, as described earlier in the period 1960 to 1980 (Tushman and Nadler, 1978) and 1980 to 1990 (Porter, 1985)

Also in this period, patterns have been represented by frameworks which, employing mapping techniques, have been used for understanding change (McWhinney, 1992). These incorporate terminology which refers to intentional acts of change as 'volitional', and refers to change caused by an external natural condition as 'deterministic'. For instance, if an organisation produced standardised methods of working that required a change in the working practices of employees; this would represent a deterministic change. The change has been imposed by a force separate from the party which has to change. Volitional change is caused by a party who would be subject of the change, such as employees who identify that a change in their working practices would provide efficiencies.

Analyzing business organizations to gain insight into current situations can be the starting point for identifying new change opportunities. A 1998 a model for changing business processes separated before- and after-change situations in a fundamental approach to change descriptions (Franken and Jansen, 1998).

At the level of software engineering, technology applications related to the acquisition, utilisation, and communication of knowledge. In the literature, information technology refers to dealing with the use of computers and computer software. One recent definition refers to securing, converting, storing, protecting, processing, transmitting, inputting, outputting and retrieving information (http://www.itaa.org/, 2010). The need to acquire knowledge was a

driver for organisation growth, with a consequent influence on developments in technology. This generally required interactions between organisations and their stakeholders. For instance, to what extent might organisations and their employees carry out activities using technology?

Review

This period was significant for developments in approaches to change, for attending to the influence of change on organisational growth, and for the increasing focus on the acquisition and management of knowledge.

> *"...Knowledge has become the most important factor in economic life….has become the most indispensable asset of corporations ..."* (Stewart, 1997 - p. 304)

Developments in technology, the early use of the Internet, and the implied level of specificity of applications in organisations, suggested increasing complexity in the context in which change takes place. Planning for change using patterns became a more frequent activity. Examples included both high-level patterns (Martin and Meyerson, 1990) and more detailed patterns (Amidon and Skyrme, 1997). Patterns, through the scope and relationships they represented, provide some control when changing technology. We refer to this pro-active approach to change as harnessing change, which, along with contained and embracing change, is representative of change situations in this period. Whilst characterising change, these descriptions also contribute to making visible the developing complexity of change in organisations.

2.2.4 2000-2010 contexts for change

The early use of information management systems and email was transformed by later developments in the post-2000 period. Organisation-wide enterprise resource planning systems were introduced, along with new techniques for managing knowledge. New business models based on technology have shown continuous growth. Amazon (founded 1994) and eBay (founded 1995) have business models based on the Internet, with subsequent growth pushing the boundaries in the use of technology. For instance, eBay, launched as an on-line auction site, had 250,000 auctions in 1996 and 2,000,000 in January 1997. By 2008, eBay had expanded its on-line business worldwide, with multiple transaction activities, and hundreds of millions of registered users. New technology was changing human activity, with on-line communications between organisation stakeholders creating new ways for exchanging information. The communities of stakeholders intrinsic to the intra-, inter-, and extra-organisation contexts communicated in ways not previously experienced. The speed and frequency of these communications provided new sources of knowledge, and emphasised a developing involvement of stakeholders in organisational change. Stakeholders were becoming a focus for changing relationships in organisations. More recently, the launch of social networking applications such as MySpace (August 2003) and Twitter (2006) introduced new channels of communication with customer communities. Stakeholder communities were brought closer to business activity, giving them the opportunity to influence developments.

In this period there has been a developing relationship between technology and business process. In Business Process Re-engineering (BPR) it is suggested that, in order to respond to change, an organisation needs to understand its business processes, and how to modify them, as well as the consequences for their installed technology systems and the constraints such systems impose on change. Grant (2002) provides a more detailed focus on BPR, suggesting that it should consider important aspects of organisations such as organisation structure, people, and communication. In the changing context there is an emphasis on impact analysis:

> *"… impact analysis techniques can represent a useful instrument for identifying the effect of change on the business process supporting software systems. In this case, the objects to be considered do not include just the software system and its components, but also the organisation, business processes, process activities, and so on; and the actions to be identified include changes to be performed on business process activities, and software systems components, in order to keep them aligned…"* (Bodhuin *et al*., 2004 - p. 4)

Another approach that refers to both business and technology is business process management (BPM). This is a structured, systematic approach to improving business processes, typically, interactions between people and machines. Goals include improving efficiency, effectiveness, productivity, and agility to foster innovation, boost quality, speed up delivery and improve customer satisfaction. This emerged from the Business Process Management Initiative (BPMI). The initiative was established in 2000 as a consortium of companies involved in e-business. BPMI aimed to promote the development of Business Process Modelling. Recently there have been efforts to establish standards for process modelling tools. For instance Business Process Modelling Notation (BPMN), which has emerged from the BPMI and has been adopted as a standard by the Object Management Group (http//www.omg.org, 2012). BPMN was first created to provide a notation for BPML (Business Process Modelling Language). Since then, it's evolved into a more general modelling notation. The latest version of BPMN was released in 2010.

In this period there have been further developments in the use of patterns when linking technology to business process. Robertson and Robertson suggest how patterns can contribute to a developing coherence between business activity and the use of technology**:**

> *"…Form your patterns by eliminating idiosyncrasies that exist in many businesses, and look for the general case. Look past the specific to see the general. Look away from the technology the organisation currently uses, to see the business policy that is being*

processed. Think of the work, not in its current incarnation, but as a model for work that can be done in the future…" (Robertson and Robertson, 2006 - p. 313).

Review

The significance of this period has been the extent to which earlier ideas in the use of technology have been implemented, the developing importance of stakeholder communities, and the expression of complexity.

The technology developments in the 1990 to 2000 period and associated suggestions for organisation development, resulted in more pro-active applications of change in the post-millennium period. The context for changing technology is now more complex than previously. Change is considered ubiquitous, with many influences affecting its implementation. Examples include the speed of technological change, the take-up of technology within organisations being different (e.g., from that of their supply chains), the variety of internal organisation situations affected by change, the more pro-active approach to change engendered by the business processes adopted, and the continuous search for competitive advantage. Whilst continuous change is an option, these influences give some indication of its impact on relations in the context where change takes place.

2.2.5 Summary

The literature review shows that change has been occurring in a context that is continually becoming more complex, with a consequent need for this context to be understood. The 1970 to 2010 timeline illustrates the variety of initiatives available to organisations today. The historical approach adopted in this review has highlighted the onset of change, how change has been represented, when and how problems have occurred, and their resolution. The growth in the use

of technology and its impact on organisation development, signals the prospect for frequent change in the future.

Whilst each historical period considered represents mixed approaches to change, the periods are distinguished by an emphasis on three approaches to change. These are referred to as contained change, embracing change, and harnessing change. Differences in each period centre on a developing growth in the use of technology, and a consequent complexity in the context in which change takes place. Today, technology is at its most advanced, and there is a continuing release of innovations to support organisations in their need to be competitive.

Complexity caused by technological change is aggravated by differences in the organisation context. There are different organisation sectors, different organisations, differences in organisation subsidiaries, different parts of organizations, and different approaches to growth. There is also different take-up and use of technology, and different approaches to change, etc. These contextual factors contribute to problems of change.

Whilst the historical periods evidence difference, there are similarities among them. All periods represent experience of the context in which change takes place, and there are recurring subjects across the periods. For instance, inter-relations when change takes place and change over time are subjects considered in all the four periods. Each period also had to cope with the problem of change which illustrates a need for problem analysis. Change has been expressed with overarching high-level descriptions of change, and more detailed descriptions of structures, techniques, notation and terminology. In the 1960 to 1980 period there were associations described between environment and its inter-relations with technology; in 1980 to 1990, more detailed categorisations of change (e.g., inter-relations in system theory) and expressions of pattern (e.g., intra, inter, extra organisation contexts). In the 1990 to 2000 period, sense-making, and stakeholder knowledge were considered, along with inter-relations in multiple contexts. In 2000 to 2010, there was a focus on engagement with stakeholders, inter-relations with change over-time, and the use of patterns. These similarities across the periods represent recurring subjects over time, and as such, a potential guide when scoping problems in the changing marketplace of today.

2.3 Reacting to changing requirements

The previous section addressed the literature on change in organisations. This section shifts attention to the RE literature, and to RE approaches that have an impact on organisation change. RE's relationship with the business process has created a new focus for research and development for the software community in general, and the requirements engineering community in particular. From 1992 to the present day RE approaches have focused primarily on green-field development (Alexander and Beus-Dukic, 2010). Yet there is acknowledgement that 90 percent of development is deployed into a brown-field environment (Hopkins and Jenkins, 2008), emphasising the need for brown-field expertise.

As with the literature review on organisation development, this section is organised in terms of timelines and recurring themes. The periods 1992-1999 and 2000-2010 are discussed in a year-by-year unfolding of problems and initiatives. The theme in both periods relates to problems in RE. In the 1992 to 1999 period we refer to 'emerging RE problems and initiatives, and in the period 2000 to 2010, 'recurring RE problems and initiatives'. The initiatives we identify offer guidance on the nature of RE problems of the day. Because they provide the basis for transformation into the brown-field context, green-field as well as brown-field structures, techniques, notations and terminology are considered.

2.3.1 1990 - 1999 – Emerging RE problems and initiatives

In this period, understanding between stakeholders and developers, and the need for a common language, were identified as problems along with the notion of changing requirements over time.

In 1992, modules and modularity were introduced, with modularity being seen as essential at the design stage in software development (Wellman, 1992). When considering change, this

ensured that parts of a system could be replaced later, with little or no disruption to the system as a whole, or to other software with which it is interfaced.

In 1992, six classes of stable and changing requirements were identified (Harker *et al*, 1992 - p. 266). The technical core of a business was seen as the stable requirement, and as an 'enduring' reference point for change in the complex context of business. The five classes of changing requirement are referred to as mutable, emergent, consequential, adaptive and migration. There was also support for the notion of patterns.

In 1994, Jarke and Pohl expressed a need to understand better the early phases of RE processes, maintain this information over time, and across traditional, technical, and organisation boundaries.

In 1996, Strens and Sugden introduced a framework focused on change analysis, which incorporated change as an integral part of the entire development process. Change analysis was handled in a better-informed way, with associated risks being made apparent. Because potential for change is identified early in the context of a lifecycle, a substantial contribution is made to minimising the adverse impact of changing requirements on project objectives. Also in 1996, computer programs were searched for patterns including language specific patterns, general and special purpose patterns, architectural patterns, process and organisation patterns (Vlissides *et al.*, 1996*)*.

In 1998, previous work on patterns (Alexander A. *et al*., 1977) was extended by Gardner *et al* (1998). In this work different varieties of patterns are defined and described as existing at all levels of abstraction. Very high-level patterns (domains) are differentiated from very low-level design patterns, with four descriptions that capture different levels of abstraction. These are domains, frameworks, cognitive maps and patterns. These 1998 initiatives illustrate the developing detail being expressed when describing approaches to problems in RE.

In 1999, the literature stated that few measurement schemes or metrics had been proposed that helped software managers manage the requirements change and evolution process. To address this problem, an action framework was proposed (Lam *et al*., 1999). There were four areas of concern: planning for change incorporates metrics for effort required for change; assessing the impact of change includes indicators required for assessment; determining

changeability, includes indicators of the likely volatility of requirements; and assessing effectiveness of handling change, includes indicators that register organisation and/or team efficiencies. Also in 1999, outcomes from nine field studies and six empirical studies which considered socio-technical scenarios created early in the development process (Harker and Eason, 1999). In this approach, the context of change is considered through the application of three different perspectives: the social and political characteristics of the systems development process; the socio-technical systems and the implications of new technical systems; and the forms in which scenarios can be represented and participants can engage with them. Previously, scenarios had been linked to use case definitions. For instance,

> *"…a collection of possible sequences of interactions between the system under discussion and its external actors, related to a particular goal…"* (Cockburn, 1995 – p. 2)

Applying use cases and/or scenarios was representative of more detailed and specific RE initiatives affecting stakeholder contexts. There were a number of perceived advantages. The focus on the boundary between computer and actors avoids detailed design of the solution before requirements are explored. Also, the natural language approach of use case/scenario facilitates stakeholder access to considering requirements. Potential disadvantages include the paucity of context information, the potential for ambiguity when using natural language, and its unsuitability for capturing non-functional requirements (Larman, 2002). The purpose of scenarios did not faithfully depict existing work processes, since these could be the subject of change. Conversely, scenarios helped users and stakeholders understand the implications of different options early in the requirements process, and assisted them in formulating their requirement for future systems (Harker and Eason, 1999).

Review

Initiatives introduced in the 1990's reflected the difficulty RE was having as a young discipline in developing approaches that produced correct requirements. Overall, the period of

1990-1999 indicates the development of two categories of problems, both of which relate to the perception of context. There were problems addressed by overarching high-level approaches to RE and change, and those addressed by more detailed RE descriptions. As separate developments, there was a risk of each being considered in isolation from the other. The overarching consideration of "a need to understand better the early phases of RE processes" (Jarke and Pohl, 1994 - p. 257) suggests an overarching approach. An exclusive focus at high level could overlook more detailed problems to which it relates, such as the need for a common language (Harker *et al*., 1993) and/or with descriptions of stakeholder activity in before- and after-change situations (Franken and Jansen, 1998).

There were a number of emerging problem subjects in this period. They included changing requirements, stable and unstable requirements, RE over time, the identification of system boundaries, engaging with stakeholders, and the use of pattern. Overall, the continuing identification of problems suggests the need for initiatives that relate to problem analysis. The incidence of problems referring to overarching and more detailed approaches suggests a problem focus on context analysis.

2.3.2 2000 - 2010 – Recurring RE problems and initiatives

The emerging problems identified prior to this period had provided a developing characterisation of both green-field and brown-field contexts. In this period these were to continue, but with an added complexity caused by the increased development of technology. Recurring problems and their characterisation became a continuing theme in the period. In 2000, Nuseibeh and Easterbrook offered an agenda-setting overview of RE. This incorporated relationships between the more technical aspects of RE and the needs of stakeholders, in an approach that referred to boundaries between different contexts. Main areas of RE practice were identified, and key research issues for the future were highlighted (Nuseibeh and Easterbrook, 2000). The why as well as the what of a system were related to the real-world goals that motivate system development. Attention was drawn to evolution over time, emphasising the

reality of the changing world and the need to reuse partial specifications. The paper stated that requirements, whilst conventionally regarded as front-end activity, often change during development and evolve after a system has been in operation for some time. It is important in requirements elicitation to identify system boundaries and stakeholders:

> *"...the identification of stakeholders and user classes, of goals and tasks, and of scenarios and use cases, all depend on how the boundaries are chosen..."* (Nuseibeh and Easterbrook, 2000 - p. 3)

RE is perceived as a process that incorporates effective communication between the different stakeholders involved in the process. To manage evolution over time, requirements should be written in a form that is readable and traceable by many, from different perspectives. RE provides negotiation opportunities for the resolution of conflicts, and managing change is a fundamental activity that should incorporate continued requirements elicitation. A number of needs are identified. There is the need for core requirements. This facilitates the development of architectures that are stable in the presence of change, whilst being flexible enough to be customised when changing requirements. There is a need to bridge the gap between requirements elicitation approaches based on contextual enquiry, and more formal analysis techniques. Reference models are needed so that the need to develop models from scratch is reduced.

A subsequent paper introduced a spiral life cycle model that encouraged developers to repeatedly evaluate changing project risks. The paper stated that:

> *"...compelling economic arguments justify why an early understanding of stakeholders' requirements leads to systems that satisfy their expectations...."* (Nuseibeh, 2001 - p. 1)

A number of initiatives followed that related to earlier problems in RE. Gross noted that little attention was being given to systematically understanding and modelling the relationships between business goals over time, and their effects on systems architecture (Gross and Yu, 2001

- p. 1). Patterns were seen to be effective in facilitating modifications and encouraging re-use in recurring situations (Pountain, 2001).

There were a number of developments in process-based approaches. In 2001, 'agile' processes were introduced to deal smoothly with changing requirements (Highsmith and Cockburn, 2001). For instance, the presence of an on-site customer and consequent on-site conversations between problem and solution owners facilitates a low-latency effect which can be beneficial in recognising and communicating change.

The strategy embedded in agile development is to reduce the cost of change throughout a project (Highsmith and Cockburn, 2001). Other authors suggest that a lighter, faster and nimbler software development approach reflects business community needs, particularly given the volatile Internet software industry and the emerging mobile applications environment (Abrahamsson P. *et al*., 2003). At this time, it was also stated that, when considering change in development processes, measurement and analysis should be incorporated from the beginning of the process improvement effort (Goldenson *et al*., 2003).

2001 also saw developments in problem-based as well as solution-based approaches. A problem is viewed as a requirement in a real-world context for which a software solution is sought. Software development incorporates a problem-solving process that leads to a solution. This satisfies the requirement in its context. Problem frames are Jackson's problem-based approach, in which the early-stage focus on the problem pre-empts:

"...rush (ing) headlong into the trap of thinking too soon about the solution …" (Jackson, 2001 - back cover page)

The problem frames approach embodies an early-stage consideration of requirements, preceding a detailed consideration and/or focus on solution. Fundamental is Jackson's concern for context:

"…the context bounds the problem: the domains are the parts of the world that are relevant…when…analysing and structuring a problem …its fundamental to determine what

it is about – that is, where the problem is located, and what parts of the world it concerns…" (Jackson, 2001 – p. 20)

A disadvantage of Jackson's approach is its focus on technical aspects of system development. The machine is the subject of design. This does not include the design of human interaction with the system (e.g., operator instructions).

In this period, the goal approach represents solution-based approaches. Goals are used for deriving requirements for a computer system from the goals of the business system which it is meant to serve, such as the goals and sub-goals used by an organisation in delivering its business processes. A current system under consideration is analyzed in its organisational, operational and technical settings. Problems are pointed out and opportunities are identified. High-level goals which have been agreed are then refined to address problems and meet opportunities. Requirements are then elaborated to meet these goals. Earlier, goal-based frameworks had been developed for redesigning organisational work. When considering inter-relationships in the system-as-is, or the system-to-be, goals provide a context from which change can be considered. This includes the separation of stable from more volatile information. The higher level a goal is, the more stable it will be (Anton, *et al.*, 1994). One example of a goal-based approach is embodied in the Tropos four-stage framework, which was introduced to reduce the mismatch between the system and its environment (Mylopoulos and Castro, 2001). Tropos incorporated an early-requirements first stage (called *i**) which studied an existing organisation setting. Also introduced in 2001 were the descriptions *a business goal* (a goal the individual or organisation has for the operation of the business) and a *system goal* (something the target system should achieve, usually a functional requirement of the target information system) (Liu and Yu, 2001).

In 2002, a comprehensive system-wide approach was introduced to balance technical considerations with social and organisation ones (Castro *et al.*, 2002). Also in 2002 a unifying framework was introduced for goal-oriented behaviour in organisations. The application of goal modelling is categorised into three areas: tasks of requirements elicitation, requirements specification, and requirements validation (Kavakli, 2002)

There are perceived advantages and disadvantages when using the goal approach. Goals represent requirements generated from high-level strategies. The advantage of using *i** can be its identification of non-functional requirements (i.e., soft goals). A disadvantage can be the difficulty of providing explicit descriptions for soft goals. A primary focus on goals (rather than context) can be disadvantageous if decomposition does not reflect the complexity of the socio-technical system in which it exists. A goal approach can potentially be too rigid where human components of the global system are concerned, given that human behaviour can deviate from that required (Yu, 1995). Yu also suggests that in organisation work it may be difficult to identify boundaries of a global system, or other top-level goals. This suggests a disadvantage when applied to those aspects of an environment that incorporate human activity in the global system boundary. Employees, in their delivery of a business process, may decide to change the boundary between non IT activity and IT activity. For instance, an employee could implement a new way of using IT in the business process. If this is not communicated to the organisation then the formal boundary between the two becomes unclear. If repeated by other employees this condition is aggravated. In this situation the organisation can no longer describe what activities are automated in the business process. This could be exacerbated further if an organisation implements rapid and/or frequent change.

In 2004 languages were introduced to express relationships between old and new systems. Examples include a notation referring to gaps and similarities. This refers to changing relationships when requirements are evolving (Rolland *et al*., 2004). Also, a framework was introduced for understanding how consistency and completeness interact in comprising correctness during requirements evolution (Zowghi and Gervasi, 2004 – p. 1). Their paper distinguishes between two views of correctness. In the formal point of view, correctness is a combination of consistency (an internal property of a certain body of knowledge) and completeness defined with respect to an external body of knowledge. Their alternative view of correctness is when it is defined as the satisfaction of certain business goals, with a customer's view of correctness being based on the satisfaction of overall business needs.

In addition, in 2005, researchers were applying Jackson's problem-based approach to the context in organisations, for instance by proposing a requirements engineering approach for e-

business systems (Bleistein *et al*., 2004). Extensions of Jackson's work also incorporated the design of human instruction (Hall and Rapanotti, 2004). Descriptions of the world were separated from that of the human. The human, as well as the machine, becomes the subject of design. This adds human description to Jackson's use of optative description (Jackson, 2001). Introducing detailed techniques and associated terminology about evolution provided further characterisation of the context in which change takes place. Developments in the problem - based approach illustrated an increasing need to understand the context from which requirements were derived.

In 2005, the business process scope of tasks, technology and people is referred to as the socio-technical system (Mate *et al*., 2005). This term provides an outline of the context to be considered when involved in an organisation activity that incorporates IT. It refers to the complex relationships that can exist in a business process, and incorporates a consideration of hardware, software, data, physical surroundings, procedures, laws and regulations.

By 2005, 'evolution requirements' entered the language of change, expressing evolution as the need to add, remove or change a requirement. Evolution requirements are in-between the before- and after –the-change situations, and are identified through reasoning about change impact and change propagation (Etien and Salinesi, 2005). Change impact identifies those parts of a system affected by change, and change propagation describes the transition from the before-the-change situation to the after-the-change situation. Four families of dependence referred to as independence, interdependence, dependence and double dependence, are used to describe impact. Each family is defined according to the direction of the dependency in evolving relationships.

In 2006, both problems in RE and their analysis were subjects of the literature. Eliciting complete and correct requirements continued to be a major challenge, with incorrect requirements cited as a constant source of defects (Gall and Berenback, 2006). Gall refers to misunderstandings brought on by the lack of a common language, or project knowledge among different stakeholders involved in early elicitation meetings. Ramzan and Ikram's survey of ten existing requirement change management (RCM) process models identifies and co-relates existing activities and artefacts. The survey indicates a lack of consensus on the RCM process.

For instance, the activity 'problem understanding' is present in 3 of the 10 models described, and actors, customer, and developer are present in 4 of the models (Ramzan and Ikram, 2006). Problem understanding was addressed by Robertson and Robertson (2006).They emphasise the importance of context by reference to ‘the work’. In their detailed description of requirements, reference to ‘the work’ includes a consideration of adjacent systems (automated systems, people, departments, organisations, etc.) with which it interacts. This approach places Jackson’s attention to context clearly in the wider business process context. Reference to ‘the work’ incorporates a separation of problem from solution in order to identify the ‘essence’, the underlying problem to be solved. Finding this underlying problem can re-scope both the existing business process being considered, and its after-the-change relationship to new technology. For example, is the supermarket queue the real essence of the problem for the supermarket, or is it the moment the customer becomes aware in the kitchen that there is a shortage of food? If it is the latter, then the essence of the problem would be in the home, and might lead, for example, to home-generated requests and supermarket home deliveries. This application of contextual awareness moves away from using an initial idea for a solution as the focus of an early-stage approach. It ensures that initial ideas are formally considered in the wider context of ‘the work’, and the context in which it operates (Robertson and Robertson 2006 – p. 68). This type of approach ensures that there is a consideration of what improvements can be made to the business process, what the work should be in the future, and how the product (the part of the work to be changed in some way – usually by automation) contributes to that work. Referred to as a ‘business use case’, it extends the previous definition of use case. The business use case scope is the business process, a much wider scope than the earlier use case scope of the system-actor boundary.

There are a number of advantages when using scenarios in a business use case. Scenarios tell the story of a business use case. They provide a narrative story-line approach, which facilitates early interaction between the stakeholder/user community and designer/developers. Understandable to all, the scenario is a neutral medium, and used by business analysts to obtain agreements from stakeholders on what ‘the work’ must accomplish. Scenarios also provide a

contextual approach to identifying domain knowledge, and they have gained acceptance by non-technical stakeholders.

In mitigating RE problems, further support for patterns were also introduced in 2006. It was stated that patterns help an understanding of requirements and support the development of abstract models based on categories rather than specifics. Abstraction helps the discovery of whether the same pattern exists in another part of the organisation (Robertson and Robertson 2006 - p. 313).

A more detailed description of requirements was introduced in 2008. A distinction is made between *requirement* and *need* (Davis *et al*., 2008). 'Requirement' indicates a documented externally-observable characteristic of a desired system, and 'need' indicates the actual need of the users, customers, market, etc.

Other authors focused on the question, why? What is it that makes some projects deal with changing requirements better than others? (De Wit and Ponisio, 2008). A correlation suggested a central role between size as a factor, and the flexibility shown, either by the organisation or by the software development team. Also in 2008 early adopters of the capability maturity model integration (i.e., CMMI) were seen to be developers of large scale risk-averse, mission critical systems, often with high-levels of management oversight, and hierarchical governance. Early adopters of agile methods generally focused on single-team development projects involved with volatile requirements in a software only environment. In 2006, the notion of agility didn't mean the absence of a set process that must be followed regardless of the product being developed. It also didn't mean the absence of all process, but more, the selection of the appropriate process, or parts of a process that are appropriate for the product or the project (Robertson and Robertson, 2006). In 2008 the previously perceived differences between CMMI and Agile were challenged in the literature (Glazer H. *et al*., Nov. 2008). They suggested that CMMI and Agile were compatible. At the project level CMMI has a focus on a high-level of abstraction on what projects do, not on what development methodology is used. Agile methods focus on how projects develop products. Therefore CMMI and Agile methods can co-exist, and complement each other by creating synergies that benefit the organisation using them. The mix of the two is situation dependant, and there is a need to assess which hybrid approaches work in which

contexts. The CMMI and Agile focus on managing the RE process was also reflected by a call for managing the changing context. The management of requirements change was seen as a crucial issue (Tanabe *et al*., 2008).

2008 represented a continuing development of the specificity with which the characterisation of requirements change was being progressed. This resulted in a refinement of the terminology being used, developments in the role of flexibility, and a re-assertion of the importance of context when considering approaches to change.

In 2009, a taxonomy (i.e., a classification) is presented as an approach for early detection of evolutionary changes to software requirements. These incorporated deep structural changes with implications for software architecture. The approach is based on using business process modelling (BPM) as a tool to increase early understanding of the problem domain. The systems stakeholders are engaged in identifying and preventing certain types of changes. This is earlier in the development process than usual with most commonly used development methods. The three stages referred to are, Initial understanding of Requirements, Changed understanding of the problem, and Changed requirements. The paper suggests empowerment to the user by involving customer/stakeholders in modelling the organisation context as a multi perspective business model. The approach identifies the earliest possible detection point (EPD) a change could have been anticipated after software project initiation. It includes a maybe model, as well as an 'as is' and 'to be' model. In characterising the problem-centred approach further it extends Jacksons reference to problem and solution space. There is a list of eight tensions between these two alternative contexts. Tensions between problem and solution space are a phenomenon that exists between the customer and the software development organisation (Mathisen *et al*., 2009).

A 2010 paper describes a collaborative tool ARARA (Artefacts and Requirements Awareness Reinforcement Agents) (De Lima *et al*., 2010). This inculcates awareness in the software development process. ARARA incorporates a business ontology which runs in parallel with the Business Process Model. The ontology provides support and facilitates the development of both the process Model and a System Design Model. The ontology was created as some concepts were new to areas in the development team, and some terms had different meanings for different stakeholders. The tool, and its incorporation of business and software

development ontology's, improves team member awareness. This occurs automatically by tracking and notifying them of requirements and/or any other changes, including potential candidates for modifications. The development of the ARARA tool suggests an increasing effort to facilitate the RE process and its recurring problems of engagement with stakeholders, the lack of a common language, and mismatches between RE and business process.

The developing need to resolve problems of context and problems of change were reflected in 2010, conference calls for papers. There were calls for evolution to be an inherent property of the system (CAiSE, 2010), an alignment with context, a coherence when business change takes place, and the need for context aware re-usable artefacts (BPMDS, 2010).

Review

In the immediate post millennium period there was a further growth of over-arching approaches to RE: developments in the goal approach; CMMI and agile development; that change should be managed; the value of continuous requirements elicitation, and the consequence of change over time. There was also the application of use cases/scenarios, and measurements and metrics for changing situations. The increasing development of technology and its impact on RE was exacerbating the mitigation of problems. More formal approaches to problem analysis turned the focus away from solutions alone, and positioned a problem-centred approach in the early-stages of the RE process. Tensions between problem space and solution space were seen as a phenomenon that exists between customer and software development organisations. Towards the end of the period RE problems reflected those related to specific moments in time, but also recurring subjects over time. Problems first identified in the 1992 to 1999 period were recurring in the period 2000 to 2010. Recurring problems suggest a problem of context over time and, as with the period 1990 to 2010, a need for a problem focus on context analyses.

2.3.3 Summary

Today's RE context reflects the increasing specificity of approaches to change. Terminology in RE differentiates new technology (referred to as green-field) from changing technology (referred to as brown-field). Initiatives for changing requirements are increasingly specialised. One example, the ARARA tool, automatically tracks changes in requirements (de Lima *et al*., 2010). Despite the progress experienced, the literature suggests that in the 1992–2010 period there has been a continuing need for a context analysis approach based on a problem-centered focus. There have been recurring problems when changing technology, incorrect requirements have been identified as a constant source of defects (Gall and Berenback, 2006); there's been a lack of involvement of stakeholders (Ramzan and Ikram, 2006); and a need for stakeholders to engage in early modeling of the changing organisation context (Mathisen *et al*., 2009). Also, whilst initiatives introduced help to address the problems identified, they also augment the terminology being used. This adds to the burden of stabilising the terminology when change actually takes place. Changing terminology, like changing requirements, is an on-going phenomenon

2.4 Conclusions

Over the last 20 years, there has been a continuing flow of problems associated with changing requirements. These problems have been exacerbated by change in the organisation context. Chapter 2 has considered this from two perspectives (based on a review of two bodies of literature): 'changing organisations' and 'changing requirements'. Unsurprisingly, different foci emerge from the two reviews: the focus in 'changing organisations' is making sense of the complex context in which change resides; the focus in 'changing requirements' is the need for a problem-centred focus on context analysis. This RE need brings these two foci together. Both

are needed to make sense of the organisation context in which RE takes place. The reviews highlight trajectories of issues and initiatives.

The organisation period 2000 to 2010 indicates how the context in which change takes place is potentially more complex than earlier periods. We refer to the 1978 to 1990 as a containing change period with its focus on internal drivers, planning for control and flexibility, and technology being a part of organisational thinking. In the period 1990-1999 both competitive advantage and the introduction of knowledge management are identified as a source of both change and complexity. This period provides examples of an embracing approach to change, a more adaptable way to accommodate change. In 2000-2010 the complexity caused by the competitive advantage external driver identified in the period 1990- 1999 is now added to by additional external drivers (e.g., speed of technological developments etc). The descriptions for the period show a far more complex and accelerating technology driven environment. Change approaches are more pro-active. We refer to these as harnessing change, with the period and its different variety of expressions of business, now being representative of containing, embracing and harnessing change. A business or part of a business could be solely on the internet, partly use the internet, or not use the internet at all. Also there could be different uses of technology by stakeholder/users when communicating with organisations. Whilst different forms of communication could be used by customers, employees, partnerships, subcontractors, suppliers etc., complexity is further exacerbated by the technology context continuously changing. New technology, its different uses, and its coming to market, is ubiquitous. As apposed to the period 1990 - 1999 change in 2000 - 2010 refers to a much greater variety of conditions existing in organisations. Different approaches to change, different take up of technology and/or growth in organisations, suggests an increased internal complexity that is then aggravated by external complexity.

There are a number of recurring problems over the RE periods considered. The reference in 1993 to Harker's concern over changing requirements is mirrored in 2001 by both Nuseibeh and Easterbrook ,and Gross & Yu. Subsequent problem-centered initiatives in the period 2000-2010 may have reduced the incidence of these problems (Jackson, 2001, Etien and Salinesi, 2005,

Robertson and Robertson, 2006) but uncertainty still exists (Tanabe 2008, CAiSE Conference 2010, BMPDS Conference 2010). There are also repeated suggestions of a lack of coming together by those involved in the RE process (Gross and Yu 2001,Gall and Barenback 2006, Ramzan and Ikram 2006,). One focus for this is illustrated by references to Stakeholders. Stakeholders are seen to be the source of all requirements (Robertson and Robertson 2006) and there is a need for stakeholders to be engaged in the early stages of the RE process (Mathison 2009). Another is the support for RE/OD integration provided by Business Process Modeling Development and Support, and Business Process Re-engineering. Recently, a lack of guidance has been affirmed, for the changing brown –field development (RESG 2010).

Overall, the trajectories identified in the reviews of recurring problems over time broadly comprise of two major categories: problems related to detailed, specific applications of structures, techniques, notations and terminology; and problems related to more over-arching approaches to change. It is recurring subjects that suggest there's been a difficulty understanding the changing technology context, especially as the context keeps changing.

Although the reviews are presented separately, the two trajectories relate to each other in a number of ways and suggest their recurring subjects are comparable: There are:

- overarching high-level of generality approaches to change;
- support to overarching approaches through detailed descriptions that add to the specificity with which structures, techniques, notation and terminology can be represented;
- engagement with stakeholders;
- inter-relations in the context in which change takes place;
- change over time;
- patterns that mitigate repeat activity;
- change analysis.

Collectively these seven subjects imply an over-time perspective on the changing context. The need for an over-time approach to changing contexts is reinforced by current research, which re-states advice from earlier literature. Changes to a software system during its lifetime

are necessary due to the growing mismatch between the system and the business it is intended to support. (Mathisen *et al*., 2009). There is also a problem of coherence. Changing contexts in organisations need to be aligned with changing contexts in changing requirements. An understanding of context is important. When contemplating context, there are multiple contexts to be considered. A multiple-context approach can minimise, or alleviate, persisting problems of context, and/or mitigate the lack of understanding that persisting problems represent (Feltovich *et al*., 1997). Together, the two trajectories of 'changing organisations' and 'changing requirements' provide historical reference and potential support for reasoning about problems of context in the present.

Support that unifies concerns of recurring problems, dealing with complexity in the present, and planning for a continuously changing context, would aide understanding. The emphasis on context is reflected in recent conference calls for 2010. First, in referring to change over time, it is stated that evolution should be an inherent property of the system (CAiSE, 2010 - p. 1). Second, there is a need for alignment with context, coherence when business change takes place, and context aware and re-usable artefacts (BPMDS, 2010). Requirements evolve or change in order to satisfy changing needs of system stakeholders. These conference calls repeated earlier advice, that stakeholders should be engaged in the changing process, and be aware of the complexity embodied in the changing context.

In general, the review shows the need to facilitate an understanding of the changing context, and emphasises the importance of engaging stakeholders in the change process. These needs are reflected in the research objective:

To facilitate an understanding of change, through client/customer and stakeholder / users experiencing a process of change.

Chapter 3. – The Conceptual Framework: Expressing Problem and Change Problem Context

3.1 Introduction

Chapter 1 introduced the research question: In an organisation brown-field context, how can changing requirements be represented, to facilitate identifying problems, and reasoning about how change should be realised? Deconstructing and reasoning about this question in the context of the reviews presented in chapter 2 suggests the following research intentions:

- First, to identify and synthesise relevant change subjects with an adaptable approach that supports accommodating a variety of organisation situations.
- Second, to develop expressive and accessible structures, techniques, notation and terminology for systematic use by client/customer /stakeholder/user.
- Third, to discover an approach for identifying patterns that provide a reliable response to a recurring change problem.

Our response is the 'conceptual framework' (presented later in this chapter). We refer to conceptual, because it facilitates the development of ideas when changing technology; framework, because it provides a systematic and structured approach to engaging with subjects of change. Overall, the framework is a high-level, 'early stage of RE' approach, offering guidance for stakeholder/user reasoning about those parts of a business process affected by change, in particular technology change. It facilitates an understanding of change, through

stakeholder/users reasoning about subjects of change. These subjects of change are derived from the literature review and represent recurring subjects from the past, complexities in the present, and the needs of change over time. They inform the framework. In working toward a common language for all stakeholders, we have included definitions of terms used in Appendices 1 and 2.

When referring to recurring problems, the literature identified contexts in which they occurred. These contexts incorporated perspectives from which change could be considered. There were high-levels of generality; detailed structures, techniques, notation and terminology; early engagement with stakeholders; interrelations when change takes place; change over time; patterns mitigating repeat activity; and the analysis of problems. These subjects are the basis for the conceptual framework's representation of problems of the past, the present, and the future.

3.1.1 Foundations from the literature

'…Software development is typically commenced when a problem is identified that may require a computer-based solution. The expression of the requirements for the new system is often informal and vague, as Jackson puts it (Jackson.M., 1995) a 'rough sketch'…'(Zowghi and Gervasi, 2004 - p. 1)

The framework does not provide a solution to a problem when change takes place, but more, a basis for understanding context and change when changing technology. It facilitates context-awareness by being flexible when identifying what to consider when change takes place. The early identification of a solution triggers the use of the framework. . Three recurring themes are evident: stakeholder/users, context, and flexibility. Stakeholder engagement provides access to their knowledge; multiple contexts provide the locations for stakeholder knowledge; and flexibility provides the ability to engage with stakeholder contexts.

Specific insights from the literature provide guidance and a continuing source of reference. First, reference is made to the control/flexibility relationship in expressing the use of

adaptability (Stacey, 1990). Control suggests a static state and flexibility refers to an adaptable state.

Second, early contact with stakeholder/users anchors the use of the framework. Stakeholders have been referred to as the source of all requirements (Robertson S. and Robertson J., 2006 – p. 46). Stakeholder/users are the source for that which represents, describes, and, when analysed, characterises the context in which change takes place. (An alternative would be an equivalent available source of organisation knowledge, such as client/customers, documented archives of legacy information, etc.) Throughout the literature review there was reference to the value of early engagement with stakeholders (Harker *et al.*, 1993, Nuseibeh and Easterbrook, 2000, Mathisen *et al.*, 2009). Early engagement is when requirement needs are at their most flexible, and early engagement facilitates the identification and mitigation of problems from the outset. For example, the impact of a mismatch of relations can be reduced by its early discovery (Strens and Sugden, 1996). Early contact also facilitates timely scoping of multiple contexts. A multiple-context approach can minimise and/or alleviate persisting problems of context, and accommodate the contribution of analysts (Feltovich *et al.*, 1997 - p. 553), individuals as experts (Clancy, 1997 - p. 270), and the locating of socially-constructed knowledge (Gibbons *et al.*, 1994).

Third, the literature review suggests the need for a common language accessible to all stakeholders (Harker *et al.*, 1993, Buckley *et al.*, 2004, de Lima *et al.*, 2010). In response to this, the language used in the framework is derived from the literature and combines structures, techniques, notation and terminology, drawn from both the organisation marketplace and requirements engineering community. There are a number of examples of similarities of language used between disciplines. The focus on engaging with stakeholders in RE (Robertson and Robertson 2006) is paralleled in organisations by their focus on stakeholders when engaged in knowledge management (KM) (Nonaka and Takeuchi, 1995). KM also incorporates evolution, which is a concern in RE (Etien and Salinesi, 2005). When considering uncertainty and change, the three variables referred to in organisations (Tushman and Nadler, 1978), relate to the three areas of concern referred to in RE (Jackson, 2001). The organisation variables refer to organisation environment, interdependencies and technology. These provide a focus for

coordinating and controlling change in organisations. The RE areas of concern refer to machine (i.e., technology) context and requirement. By separating solution from problem these three concerns reduce complexity when considering problem analysis. Organisation interest in the what, why, and how of change (Amidon and Skyrme, 1997) is also paralleled in RE (Nuseibeh and Easterbrook, 2000). Patterns have been a subject in RE (Pountain, 2001), as they have been in organisations (Robertson and Robertson 2006).

A flexible approach to developing this language facilitates adaptability for the stakeholder context being considered. Terminology used by stakeholder/users can be incorporated. We are guided by a view of the precise nature of requirements, specifications, and domain knowledge, which states that:

> *''…all descriptions involved in requirements engineering should be descriptions of the environment.…with the terminology used grounded in the reality of the environment for which a machine is to be built…''* (Zave and Jackson, 1997 - p. 2)

Fourth, we characterise the context in which change takes place, by the framework's representation of a 'level of generality'. We refer to a high level of generality and a low level of generality. A high level of generality incorporates general descriptions and a low level of generality more detailed descriptions. Descriptions in the approach (referred to as explicit descriptions) require responses from stakeholder/users. For example, the word 'context' would represent a general descriptive request requiring a response from stakeholder/users. Adding to this the words, partnerships, subsidiaries, sub-contractors etc would represent more detailed descriptions. Explicit descriptions and the stakeholder/users subjective responses express the question and answer technique used for examining the changing context. Whilst organisations can determine what the explicit descriptions will be, the approach we present refers to a high-level of generality. A high-level of generality alleviates complexity caused by uncertainty and fluidity (Jackson, 2001 - p. xvi). It also facilitates application to a wide variety of organisations. Application to a wide variety of organisations facilitates comparisons being made between

organisations. This aids the comparison of different organisation change situations and hence the identification of patterns of change activity. A reference model for requirements and specifications offers the notion of:

> *"…frameworks that provide for talking about key artefacts, their attributes and relationships at a general level, but precisely enough that we can rigorously analyse substantive properties…"* (Gunter *et al*., 2000 – pp. 37-38)

Fifth, the literature review identified the need for a problem centred focus on the analysis of context. We refer to this throughout as 'change problem context'. The scope we adopt for this context is based on the transition from a current business process to an improved business process. This incorporates change and migration. In the literature review, an early focus on this context was the test-bed project in the period 1990-2000 (Franken and Jansen, 1998). When applied to problem analysis, an early-stage RE application provides a timely consideration of the problem.

Therefore our change problem context approach centres on applying three expressions of change each of which originates from the literature. These provide the focus for reasoning about change, and ultimately, the basis for identifying subjects for design when changing technology:

- The reference to change over time when describing evolution requirements (i.e., identifying those parts affected by change when moving from a before-the-change to an after-the-change situation (Franken and Janssen, 1998).When considering inter-relations, we refer to the language of gaps and similarities (Rolland *et al*., 2004); relations between consistency, completeness and correctness (Zowghi and Gervasi, 2004); and, reference to four families of dependence (i.e., independence, interdependence, dependence, and double dependence (Etien and Salinesi, 2005).
- The consideration of change when determining what non-IT/IT activity might or might not be automated when change takes place (Robertson and Robertson, 2006).

- The reference to separating the problem context from that of the solution context to clarify the distinction (i.e., concerns) between the component parts considered (Jackson, 2001).

Whilst the approach adopted provides flexibility in the way it reflects an organisation context, common to all applications is the incorporation of each of the three expressions of problem.

Table 1 provides a comparison of the three different approaches to problem context.

	C1	C2	C3	*C4*
R	*Change context characteristics*	*Jackson (2001)*	*Etien&Salinesi (2005)*	*Robertson & Robertson (2006)*
R2	Static	Change		
R3	Dynamic		Changing	Changing
R4	Problem approach	Requirement/ Context/Solution	Co-evolution	Satisfied Need/ Need for Service/ Business Service
R5	Analysis focus	Problem	Changing over-time	Business process
R6	Change focus	Technology change	Evolution change	Business change
R7	Driver for change	Identify problem	Co-evolution	Improving non-IT/IT relationship
R8	Relations	Problem/solution	Before-the-change to after-the-change	Business problem/solution
R9	Overall context	Problem context	Changing context	Business context

Table 1 - Problem Context

In the table, comparing the characteristics of the three approaches (C2, C3, C4) with the change context characteristics (C1), illustrates differences between them. The *Analysis focus* (R5) for Jackson (C2) is problem; for Etien & Salinesi (C3), Changing over-time; and for Robertson & Robertson (C4), Business process. *Change focus* (R6) for Jackson is technology change; for Etien & Salinesi evolution change; and for Robertson & Robertson, business change. When considering *Relations* (R8) the context for Jackson is based on a consideration of problem and solution. For Etien & Salinesi, the context is based on before-the-change to-after-the-change; and for Robertson & Robertson, business problem and business solution. The

Overall context (R9) for Jackson is the problem context, for Etien & Salinesi, the changing context, and for Robertson & Robertson, the business context.

The rest of the chapter describes: the basic elements of the conceptual framework; the foundations of the change problem; before-the-change and-after-the-change artefacts; the evolution requirements artefact; the fit between the conceptual framework and case studies. Italics are used to emphasise important terminology (i.e., when introducing significant words for the first time). The following terminology is used regularly throughout the thesis. There is a complete list in Appendices 1 and 2 (Glossary A-B):

Artefacts - represented by before-the-change, after-the-change and evolution requirement descriptions.
Business process - context of business activity identified by client/customer-stakeholder/users.
Business and requirements analysts - third party contributors to the reasoning process
Client/customer - represents those with a deterministic influence on business process.
Context - general description for scoping a situation/circumstance.
Environment - context in which an organisation operates.
Evolution of requirements-composed of evolution requirements and requirements evolution (Etien and Salinesi, 2005)
Interrogate - examine by questioning.
Level of generality - relationship of explicit descriptions in the approach (i.e., determined by client/customer) requiring subjective responses from stakeholder/users.
Non-IT/IT - in a business process, the relationship of non-IT activity to activity contributed by IT.
Notation - an aspect of codification representing a system of figures, signs, symbols
Socio-technical system - complex system of tasks, technology and people (Mate et al., 2005)
Stake/holder/users -those with a *volitional* influence on business process.
Variable - a fluid state, rather than a static state.

3.2 Basic elements of the conceptual framework

The conceptual framework responds to questions raised in the literature review by facilitating an understanding of the changing context. It aims to provide a unifying representation, reconciling the characterisation of change in its different organisation settings.

This first section scopes the context in which change takes place. It provides the boundaries for considering the first expression of problem. This relates to identifying the *essence* of a problem when reasoning about changing technology in the context of business process (Robertson and Robertson, 2006 – pp. 107-109), for instance, when reasoning about existing

non-IT/IT problems or what might be automated in a business process. The change problem is described, and an account is given of how it differs from a development problem.

3.2.1 Expressing organisation change problem context

We introduce the term *organisation change problem context.* It represents a difference from the context of a development problem. Associating problem to change also signals a focus on a context-awareness of relationships when change takes place. In the development problem-based approach, it is typical to seek a new solution to the problem. Change problems are different. As described in Franken and Jansen (1998), when change takes place, an existing situation has to be adapted to meet the change required. In Jackson's approach, it is typical to begin problem analysis with the description of the problem context, the domains in the real-world that form the context of the problem for which the solution is being sought, together with the description of the requirement (i.e., the changes to the problem context the solution is supposed to bring about). A change problem requires an adaptation of a current situation to the change required, and is achieved through understanding the context of the required change, and an identification of those parts of an existing situation affected by the change (Brier *et al.*, 2006 – p. 2).

In our approach, the organisation change problem context contains and bounds the change problem. Applying the framework facilitates understanding a required change, through identifying those parts relevant to the problem and understanding how they are connected. The basic elements of the framework are referred to as before-the-change, after-the-change, and evolution requirements and incorporate symbols and expressions for guidance when making descriptions. They are, illustrated in figure 1.

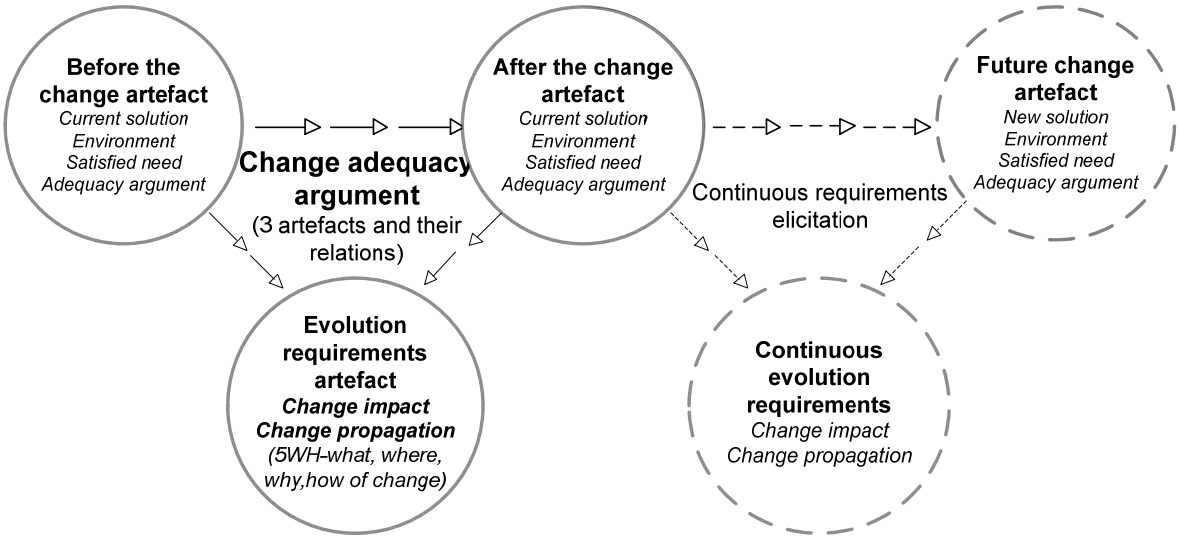


Figure 1 - Organisation change problem context

In the figure, the first step of applying the approach is represented by before- and after-the-change and evolution requirement artefacts. The before-the-change descriptions are identified first. These represent the existing business process in the organisation subject to change. After-the-change descriptions follow; they represent the changes made. Evolution requirement descriptions are then abstracted from a comparative analysis of before- and after-the-change descriptions. A change adequacy argument confirms alignment relationships between the three artefacts described. The approach can also be applied iteratively, with refinement of the artefacts after they are considered singly, and in relationship to each other. This form of fluid iteration is indicated by the dashed lines, arrow heads and circles. This process provides intelligence that informs context analysis (e.g., re: individual, group, organisation).

Completing a change adequacy argument facilitates mismatch-free relations when reasoning about the three artefacts of a change problem context and their relationships. The use of change adequacy arguments is grounded by reference to Zowghi and Gervasi's view of correctness. Consistency refers to situations which have no internal contradictions, and completeness refers to everything that is desired to hold in a certain context. When consistency and completeness exist together, they represent correctness (Zowghi D. and Gervasi 2004). Referring to Zowghi and Gervasi facilitates arguments that aim to represent a mismatch-free, aligned business process that is complete, consistent and correct. It confirms a consistency of business process

between before- and after-the-change descriptions when considering evolution requirements, and has to be addressed as part of problem analysis of change problem context. It is used as a form of validation that the business process supports the need identified in the given context.

The organisation change problem context defines the changing context. It also identifies the business process which is the subject of change, and the boundaries for considering the first expression of a problem. It provides the opportunity to focus on identifying the essence of a problem when reasoning about changing technology within business processes (Robertson and Robertson 2006). This could include reasoning about existing non-IT/IT problems, or considering what might be automated in a business process. The change problem context reflects its derivation from the literature and the basic features of the approach. There is the suggestion of multiple contexts being considered and an implied context-aware approach to reasoning about relationships, both within and between artefacts. Through the application of adequacy arguments, there is an implicit notion of process that relates overarching ideas to more detailed considerations of context, and a confirming of alignment coherence. This refers to the previously-described approach to 'level of generality' (Foundations from the literature, 3.1.1). Also, relating the evolution requirement artefact to before- and after-the-change artefacts signifies a perspective on change over time.

3.3 Change problem foundation

Reasoning about relations between non-IT and IT activity incorporates describing task, technology, and/or people alignments. Before-the-change and after-the-change artefacts embody the second expression of the problem. This refers to Jackson's approach to structuring problem analysis by separating problem from solution. (Jackson, 2001). Before- and after-the-change artefacts enable stakeholder/users to reason about task, technology and people change problems. Descriptions of environment are separated from descriptions of changing technology.

3.3.1 Change problem terminology

Before-the-change and after-the-change notation has been derived from the literature.

3.3.1.1 Environment and system

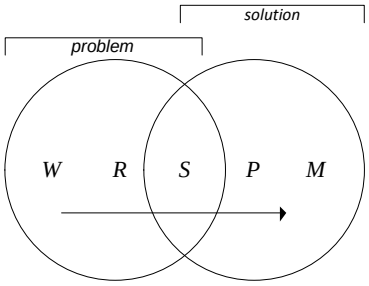
In 2000, Gunter *et al*. drew attention to the wide variations in the use of terms when comparing user requirement and software requirement specifications, noting that:

"…Requirements for software often fall into two categories: for those who commission, pay for, or use it and for those who program it…" (Gunter *et al.*, 2000 – pp. 37-38)

Gunter *et al* introduced a reference model that separates system from environment. The model is based on artefacts broadly classified into groups that relate mostly to the system versus those that relate mostly to the environment. This is a framework for reasoning about the separation of the machine, the environment in which it is to be used, and the requirement. These three components are illustrated in figure 2.2a, where the problem is located in the environment (w), the solution is represented by the specification (s) in the machine's (m) program (p). When the program (p) is realised in the environment (w) this satisfies the requirement (r). The development process assumed by the model is one from the world (where the problem is - w) to the machine ellipse (where the solution is - m) as represented by the arrow.

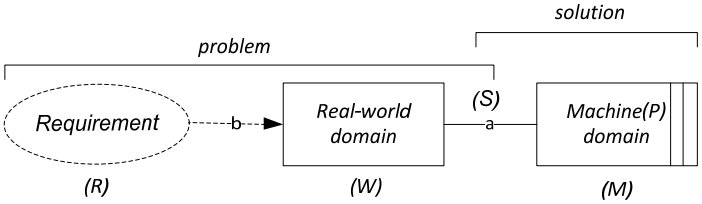
This mapping of the requirements engineering process is concretised in figure 2.2b in Jackson's problem-based approach to requirements engineering (Jackson, 2001). An understanding of the problem context is facilitated by separating descriptions of problem from descriptions of solution. In the figure, *Specification (S)* represents the interface between *Real-world domain (W)* and *Machine domain (M)*. Both diagrams are modified by the addition of the problem and solution signifiers to illustrate how they are located in each diagram. Jackson's approach brings the domains and the requirement together. His focus on locating and bounding

the problem expands and clarifies the distinction between the three components considered, and their alignment. In Jackson's approach, the problem resides in the *context*. The contribution of the *machine*, when realised in the context, meets the *requirement*.



2.2a

(Gunter et al., 2000 - p37-38)



2.2b

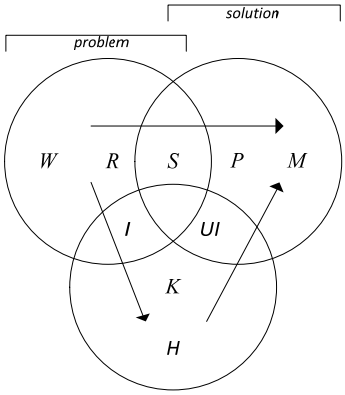
(Jackson, 2001 – p.20)

Figure 2 - 2 ellipse model

3.3.1.2 Environment, system, and human

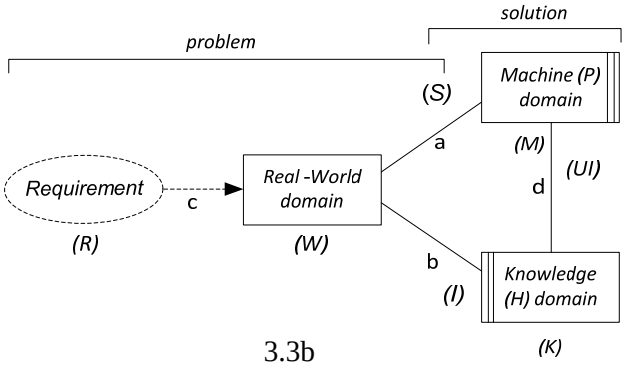
Figure 3 illustrates how a change problem differs from a development problem. This is shown in the context of technology change in organisations. Figure 3.3a, from Hall and Rapanotti's socio-technical development approach, uses 3 ellipses to represent the *world*, the *machine* and the *human*. Figure 3.3b re-interprets this as a diagrammatic problem-based representation. Figure 3.3c illustrates the 3-ellipse model interpreted for change in organisations with its problem-based representation in figure 3.3d (i.e., both taken from Brier *et al*., 2005). The following modifications have been made. In 3.3d, the interface description notation (e.g.

ORC//OT, etc.) and the inclusion of the delta symbol for change are included from 3.3c. These have been included to echo their representation in 3.3c. Also added are the problem and solution signifiers to 3.3c /d. This identifies where they are located in each.



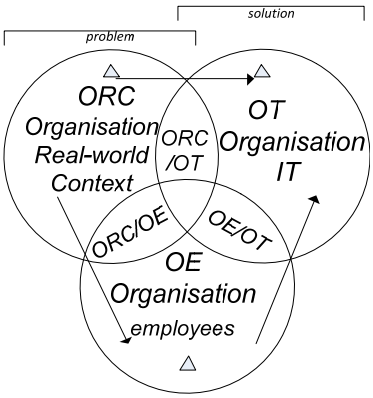
3.3a

(Brier *et al*., 2005 - adapted from Hall and Rapanotti - 2004)



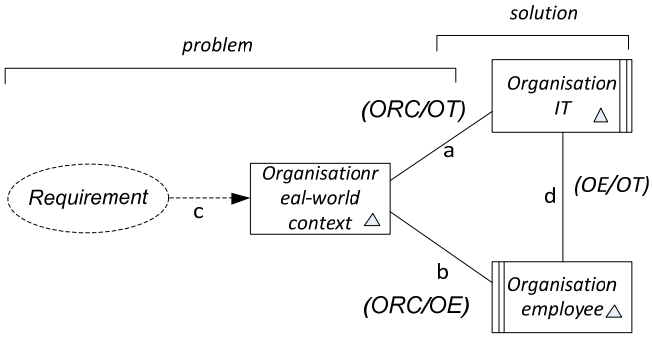
3.3b

(adapted from Brier *et al*., 2005a)



3.3 c

(adapted from Brier *et al*., 2005b)



3.3d

(adapted from Brier *et al* 2005b)

Figure 3 - 3 ellipse model

The adaptations in each figure refer to additional notations. For example, the addition of problem and solution signifiers on each diagram, and interface descriptions in 3.3c and 3.3d.

In the figure, 3.3c shows the 3-ellipse model with each ellipse now representing an organisation context. When compared to figure 3.3a it can be seen that the Machine *(M)* has been replaced by *OT* (*Organisation IT)*. OT represents those aspects of the organisation that are technology driven. Knowledge *(K)* is replaced by *OE (Organisation employees)*. This represents the human component in the organisation. World *(W)* is represented by *ORC (Organisation Real-world Context)* in a representation of the organisation's context of operation. The location of change is represented by the delta in the figure (i.e.Δ). This identifies where change can take place and includes optative social as well as optative technology descriptions. When considering the interface descriptions, *ORC/OT* represents the Organisation Real-world Context/Organisation IT interface; *ORC/OE* the Organisation Real-world Context/Organisation Employee interface; and *OE/OT*, the Organisation Employee / Organisation IT interface. The resulting development process, indicated through the arrows in the figure, proceeds from the Organisation Real-world Context (where the problem is) to both the social and technical ellipses (where the two parts of the solution are). Overall, *ORC/OT*, *ORC/OE* and *OE/OT* must guarantee that the requirements of the socio-technical system are satisfied.

The result of converting figure 3.3c into a problem-based representation is seen in figure 3.3d. As a problem-based representation3.3d remains structurally the same as the problem-based representation in figure 3.3b. This includes the problem and solution signifiers. The changes made to 3.3d from those in 3.3b are as follows. *Organisation Employee* replaces *Knowledge (H) domain; Organisation IT* replaces *Machine (P)* domain; with the *Real-world domain* becoming the organisation's context of operation (i.e., *Organisation Real-world Context*). Examples include partnerships, regional offices, suppliers and customers etc.

3.4 Before- and- after-the-change artefacts

Figure 4, Change diagram, illustrates the development from figure 3.3d, to an organisation, problem-centred, change notation.

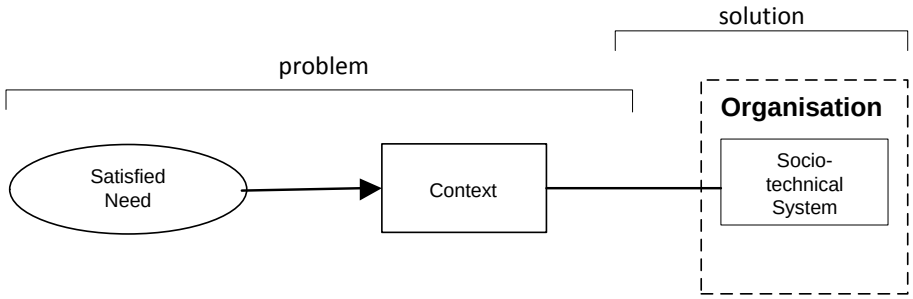


Figure 4 - Change diagram (Brier *et al*., 2006)
(NB: Problem and solution signifiers added)

The figure represents the interpretation of Jackson's approach. It reflects the needs of before-and-after-the-change descriptions. Jackson suggests that:

> *"…you are relying on the domain properties to bridge the gap between the specification phenomena that the machine can directly sense and cause, and the requirement phenomena that your customer is interested in…." "… that is why it is important to bring the domains and the requirement together…"* (Jackson, 2001- p. 56)

In the figure, the problem resides in the *context* (in which the organisation operates) where *organisation* (replacing machine) has to meet *satisfied need* (replacing requirement). The context is at the centre of the analysis. The approach relies on domain properties (i.e., in *context*) to bridge the gap between the service provided by *Organisation,* and the satisfied need in which the customer is interested. The diagram provides descriptions of the organisation

problem. This includes the domains in the real-world from which the solution is being sought, together with the description of the requirement (the changes to the problem environment the solution is supposed to bring about). The problem-based approach to descriptions of phenomena and their sharing and control, is adopted. For simplicity, these are omitted in the diagram. The notation incorporates an application of an adequacy argument (i.e., similar to the previously-described change adequacy argument). An adequacy argument has to be addressed as part of problem analysis of before- and-after-the-change contexts. It confirms a consistency of business process. The service provided by *Organisation*, meets *Satisfied Need* (service quality), in the descriptions of *Context* (i.e., need for service). It is used as a form of validation that the business process supports the identified need in the given context.

Jackson's technology-based representation of "observable behaviour and/or effects" is extended to include Hall and Rapanotti's incorporation of employee actions. Descriptions are scoped by reference to a socio-technical system of tasks, technology and people (Mate *et al.*, 2005).

Referring to the literature has advanced the development of a notation for before- and after-the-change descriptions. Further refinement and amplification occurs from considering a number of real-world studies. These facilitate the identification of similarities with the literature review, and the discovery of additional notation for inclusion in the approach. Both reinforce the basis for the approach.

3.4.1 Real-world studies

The question being addressed by Real- world studies (referred to as case studies) is: To what extent are relationships between case studies and foundations from the literature such that the conceptual framework's structure, notation, techniques and terminology represent abstracts from each?

This research adopted a case study approach. Given the timescale and scope of the PhD, using existing material allowed reference to a greater variety of socio-technical situations than would have been possible if, for example, information had been sourced from a new study.

The case studies have been sourced from the literature, e.g., (http://www.idea-group.com). An initial group of 33 case studies was reduced to 19, selected for their focus on representing and describing change in technology. The list of case studies considered is in Appendix 3 with their short descriptions intimating why some were excluded. There were a number of different reasons. These included a lack of focus on change (e.g., IT5503), descriptions centred on managing the wider context of change (e.g. IT5511) and cases centred on the business/financial process of change (e.g., IT5175). The studies refer to timescales from 1979 to 2003. The case study descriptions are summarised as follows:

- There were 7 organisations based in North America, 3 in South America, 4 in Europe (1 UK), 2 in Australasia, 1 in the Netherlands, 1 in Guam and 1 in India.
- There were 6 governments, 11 private and 2 anonymous organisations.
- Government agencies, financial institutions, health organisations, IT organisations and media companies were represented.
- 15 case studies described change in an organisation-wide context, and 4 examples described change in a specific part of an organisation (e.g., office system).
- 17 case studies described evolutionary changes; 2 described a one-off project change.

3.4.2 Stage 1- data profiles

There were four stages of case study interrogation:

1. Stage 1 arranged data under subject headings. These headings represent similarities between case studies (Tables 2/3). This stage also identified relationships between categories identified in the literature and case study information (Table 4).
2. Stage 2 (3.4.3) added to the framework, case study information on structure, technique, notation and terminology.

3. Stage 3 (3.7.1) identified the fit between case studies and the conceptual framework.
4. Stage 4, presented in chapter 5 (5.2), illustrated an approach to discovering patterns, and identified a more detailed level of generality than in the conceptual framework (data in Appendix 4.2)

Stage 1 (Table 2 and 3) was largely a data-driven pass where individual case study characteristics were profiled under subject headings reflecting change context descriptions (e.g., Column A - subject of change). These subject headings represent generic similarities across the group of case studies. The stage 1 approach arose from an iterative process which identified subjects to be considered. There were two sources. These included those that recurred in all the case studies (e.g., Column I - scale of the change) and subjects in case studies that were referred to in the literature. An example includes a reference in each case study to different organisation levels or contexts when considering change (e.g., Column H - level of change). Different organisation contexts were also referred to in the literature (Porter, 1985). The descriptions contributed by each case study are also influenced by concepts in the literature (section 3.1.1). They refer to stakeholder/user reasoning being represented by descriptions of observable behaviour and/or effects (Jackson, 2000); and the need to ground descriptions in the reality of the environment in which technology is to be used (Zave and Jackson, 1997 - p. 2).

Table 2 - Case studies 1-10 (stage 1 data)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	Subject of change + Town/City/ Local/Agency Region/ National	**Add, remove replace technology**	**Org wide and/or subsidiary**	**Quality, Cost, Delivery**	**Country**	**change reason+ Enabler,Lever, Foundation**	**change type**	**Level of change**	**scale of change**	**Subject area**	**Time Scale**	**level of granularity**	**Aspect of Case Study used**	**Business Process**	**Business Services**	**Technology described**	**alignment?**	**Knowledge Management**	**Evolution evident**
S.1	**Implementing workflow management software** - national public company	**REPLACE** Historic changes described- potential tracking etc- plus KM	Org wide	Quality improvement re: workflow process	Germany	upgrading workflow management- **ELF Processes**	operational-software upgrading-reengineering	sw-operational	publicly quoted company-detailed workflow described	media company	1990-2000	operational detailed-ie:workflow	Live project	improve process automation-integrated archiving solutions-managing		SAP R/3 plus IXOS ARCHIVE (Knowledge repository)	Business document management system with workflow solution	IXOS = knowledsge repository of org memory re: org. knowledge distribution	Yes
S.2	**Electronic Workflow implementing EDI** - Gov.Agency	**ADD** evolutionary changes described	organisation wide	QCD page 1	USA	Increased competition - using IT to improve business process **ELF=Process**	operational software-EDI	sw - operational	National company, detailed workflow described	National Laboratory for Government Projects	1995-2003	operational detail (workflow)	Live project	process automation		evolution systems described	elecronic workflow		Yes
S.3	**Network Implementation-** Development Agency - tourism, food, manufacture	**REPLACE**	Office system	Quality - p4	Scotland	IT to improve service quality **ELF-Network**	HW/SW-operational	HW/SW-operational	Local Area Office	Government Business Agency		Internal-ext. network	Live Project	network automation	improve service quality	layout of network - no spec	Agencys with Head Office	by implication	No
S.4	**Provision of electronic delivery/analysis of financial data.** A 3.5billion subsidiary of a private company	**REPLACE**	subsidiary relationship with owner company	Quality re: improving BtoB services within the organisation p488	North America	Head Office requires a common platform for its subsidiaries- **ELF processes**	SW-operational	HW/SW operational	Divisional Office (6 divisions)	Integrating finances of 6 divisions exampled by one division	2002	sw spec	Live project	Improving BtoB service within the organisation		Description - eg SAP ERP but no spec.	alignment of evaluation and delivery of financial info with dissemination to 6 divisions (ie: process improvement)	by implication	No
S.5	**Electronic improvement of audit capability**- Benefits Office of an International Union	**ADD +** evolution potential	subsidiary	IT enhancing operations-p9	USA	CEO believes IT can enhance operations- **ELF Network (internal)**	SW/HW	operational-workflow	subsidiary	IT -mini computer system for benefit services	1979-1998	sw description-no spec.	Live project	enhancing operations	provision of benefits-audit capability	description plus some evolutionary spec	New IT with business process	by implication	Yes - 1979-1998
S.6	**Electronic support for a TQM model**-a subsidiary with IT management responsibility for a large Corporation	**ADD +** evolution potential	subsidiary	IT support for a TQM programme + use of Balanced Scorecard	Peru	IT support for the TQM model **ELF Network (internal)**	sw	operational workflow	Corporate IT application to 2000 subsidiaries	Implementing QD Monitor (sw) incorporating the Balanced Scorecard	1979-2000	sw descriptions and some spec.	Live Project	IT evidence that the improvement strategy is under control	Btob support (internal)	described with some spec.	IT support for business process	Continuous Quality Improvement Programme	Yes - 1979-2000
S.7	**Prov. of electronic network (WAN/LAN),real estate firm,**14 offices	**ADD** + evolution potential	org. wide	QCD page 13	USA	Implmenting WAN/LAN- **ELF Network**	sw/hw	operational networking-employees	org application to 14 offices	wan/lan network	1996-2001	sw descriptions and some spec.	Live project	linking offices to enhance connectivity	btob internal support-employees sharing knowledge	configuration described with some spec.	network support for business process	network providing sharing of knowledge	yes-1996-2001
S.8	**Vid/conference telemedicine-customer/patient hospital contact**	**ADD**	organisation wide	by implication	New Zealand	improving remote service- **ELF-process**	sw/hw	operational - service	hospital to patient contact	providing remote patient access	1993-1996	process description	Live project	provision of remote patient access	provision of remote patient access	description	IT driven business process/business service	by implication-provision of!	No
S.9	**Implementing internal / external Enterprise Resource Planning (ERP)**	**REPLACE**	organisation wide	competitive advantage - p2	USA-global company	improving employee, customer, supplier linkage process- **ELF process / network**	sw/hw	strategic/ operation application	global cross organisation, employee, customer, supplier	ERP implementation in a global setting (process)	1996-2000	process description-	Live project	employee, supplier, customer contact	internal btob support	description	employee, supplier, customer	competitive advantage -p2	yes
S.10	**Technology implementation to align business strategy and structure** - food industry	**ADD**	organisation wide	QCD-p159	Greece	an integrated system increasing flexibility in managing enterprise resources-**ELF process / network**	sw/hw	strategic/ operation application	internal and supply chain	additional sw applications	1999+3 - 5 yr. planning	strategic intent, operational applications	Live project	process-additional sw content	support for….BS	description	comprehensive info. p158	throughout-eg:p156/159 etc	yes

Table 3 - Case studies 11-19 (stage 1 data)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	Subject of change + Town/City/ Local/Agency Region/ National	**Add,remove replace + evolution potential**	**Org wide and/or subsidiary**	**Quality, Cost, Delivery**	**Country**	**changereason+ Enabler,Lever, Foundation**	**change type**	**Level of change**	**scale of change**	**Subject area**	**Time Scale**	**level of granularity**	**Aspect of Case Study used**	**Business Process**	**Business Services**	**Technology described**	**alignment?**	**Knowledge Management**	**Evolution evident**
C.S.11	**Internet/ intranet based e-business applications**-German Bank	**ADD**	organisation wide	KM and comp. advantage throughout	Germany	internet based e-business applications **ELF process/ network**	sw/hw	strategic / operational application	global rollout to customers and new markets	internet based business applications	1999-2001	process description	Live Project	contacting customers and new markets globally	support for….BS	system analysis, design, programming, testing,rollout	IT to needs and opportunities	Fundamental-p1	Yes
C.S.12	**Integrated MIS system -** Govmnt. agency	**ADD OR REPLACE**	org wide	quality of process through automation	USA	automating the integration of product and functional processes-**ELF process**	sw/hw	operational	organisation wide	integrating MIS	mid 1990's-spanning 10 years (p123)	strategic and process description	Live project	integrating process	improving support	components and processes described	automated configuration to align acquisition / procurement process	by implication	Yes
C.S.13	**SAP R/3 upgrade** - Corporate Services Govmnt. Agency	**REPLACE**	org wide	process emphasis on cost-travel expense management	Australia	integration of information systems - **ELF process**	HW/SW-operational	operational	organisation wide	travel expense management	1996-2002	strategic intent-operational activity	Live project-travel management	integrating IT process-process management life cycle - p322	managing costs	description - some spec.	IT	KM through improved process	Yes
C.S.14	**Head office / Group call centre IT integration -** International Truck business	**REPLACE INTERMEDIARY**	Group wide	process emphasis	USA	integrating call centre IT activities - **ELF process**	hw/sw	strategic / operational application	group wide	call centre handling of user problems	2000-2003	strategic intent - operational activity	Live project	IT process improving user satisfaction/ productivity	user satisfaction	description plus sme spec.	IT call centre activity	KM through improved process	yes
C.S.15	**Concept: link between info req. and perceptions of reality -** a life insurance company	**ADD**	Group wide	Quality of flexibility - p4	Netherlands	Quality of conceptual schema for flexibility and change - **ELF process**	sw	operational	org. wide	integrated benefit admin info system	1996-1999	strategic intent - operational activity	Live project	process IT info system	Benefit admin IT info system	description plus some spec.	CS providing linking between req and perceptions of reality	KM through IT process development	yes
C.S.16	**IT for Import and Export info Reports** at a Govnmt Agency	**ADD INTERMEDIARY**	Agency wide	Quality information	Guam	converting process to IT - **ELF-process**	sw/hw	operational	org wide	export / import reports	80's 90's	strategic intent - operational activity	Live project	import / export reports using IT	using data/a resource for economic development	descriptions	IT and business process	by implication	yes
C.S.17	**IT for Knowledge Management** - International Organisation	**ADD**	organisation wide	Quality - p 246	India	multiple process improvements - **ELS process**	sw/hw	operational	org wide	additional IT content/centralised and de-centralised functions	1992-2002	strategic intent - op. activity	Live Project	additional IT content/centralised and de-centralised functions	a KM strategy-a content, people, technology, process	descriptions	KM linking IT with business objectives	Yes	Yes
C.S.18	**Business Reengineering** - Large Govnmt. Agency	**REPLACE** - legacy changes described-potential tracking etc	theoretical example-organisation wide	quality through critical measures of performance and customer value - p11	USA	Reengineering-business processes-**ELF=Processes**	operational -9 software programmes +system actions-mainly proj man people emphasis	SW-operational	Head Office and USA wide Field Offices	Delivery of employee benefits (eg: health)	12 weeks	operational detailed-ie: system actions-technology described-no specs	Hammer (1993) and Davenport (1993) example of ideal in case study	reengineered 9 business processes	internal btob support	comprehensive descriptions and system actions	IT and business process	by implication	Yes
CS 19	**Networking regional offices** - Govnmt. Organisation	**ADD** - org wide ex including reg. offices	organisation wide	re:process - p260	Peru	Networking for customer - employee benefit-reengineering-**ELF Networks**	WAN for 13 regional offices linking clients to the ST system-potential tracking example with multiple changes	HW/SW-operational	Countrywide 13 regional offices linked to head office	Public Registry modernisation	1994-2002	operational-local offices linked to head office-technology described spec.	including historic changes with the focus on the WAN	head office networked to countrywide offices	internal btob support	descriptions and spec.	IT and business processes	by implication	yes

The guidance derived from the 'Foundations from the Literature' section is reinforced by relationships identified between its three problem approaches and case study information. This is illustrated in Table 4. Similarities and differences are recognised by comparing C1 - Case Study Subject Characteristics, C2 - Organisation Literature, and the three expressions of problem context represented by C3- Jackson (2001), C4 – Etien and Salinesi (2005) and C5 Robertson and Robertson (2006).

	C1	C2	C3	C4	C5
R1	*Case Study Subject Characteristics*	*Org. Lit.*	*Jackson (2001)*	*Etien & Salinesi (2005)*	*Robertson. & Robertson (2006)*
R2	Column B - Add, remove, replace	org lit	Change	Changing	Changing
R3	Column D Quality/cost/delivery	org lit	Requirement/ Context/Solution	Co-evolution	Satisfied Need/ Need for Service/ Business Service
R4	Column F - Enabler, lever, foundation	org lit	Problem centred analysis	Changing over-time	Business process analysis
R5	Column N Business process	org. lit			Business context
R6	Column S Evolution evident	org lit	Identify problem	Co-evolution	Improving non-IT to IT
R7	Column Q Alignments	org lit	Problem/solution	Changing	Business problem/solution
R8	Column R - Knowledge managmt	org lit			
R9	Column C Organisation-wide	org lit	Problem context	Changing context	Business context
R10	Column H Level of change	org lit	Problem context	Changing context	Business context
R11	Column I Scale of change	org lit	Problem context	Changing context	Business context
R12	Column L Level of granularity	org. lit	Problem context	Changing context	Business context

Table 4 - Case study characteristics /Problem context

In table 4 there are 6 columns and 12 rows. The first row R1 incorporates 5 subject headings: Case study characteristics, organisation literature review, Jackson (2001), Etien and Salinesi (2005) and Robertson and Robertson (2006). Comparing descriptions facilitates identifying relationships between the reality the case studies represent, and information abstracted from the

literature review. The following example indicates how the table asks questions of the approach which the conceptual framework is intended to provide.

First, when identifying similarities, the case study characteristics identified in C1 have all been referred to in the organisation literature review (C2), and, with the exception of R5/R8, can be seen to have relationships with C3/C4/ and C5. Information included in the framework from the literature review (i.e., C3/C4/C5 - three expressions of problem) is reinforced when similarities are found to exist between Case Study Subject Characteristics and C3/C4/C5

Second, R5, Business process, is found in case studies and the literature review, but only in one of the expressions of problem (e.g., Robertson and Robertson, 2006). This suggests a mismatch and a potential unification /coherence difficulty when combining the three expressions of problem in the same conceptual framework process.

Stage 1 and its Tables 2/3 have provided the opportunity to compare similarities between case study information, and identify relationships (expressed as subject headings) that represent commonalities across the case studies. Table 4 provides the opportunity for a similarity and difference comparison of case study and literature review information. This facilitates identifying alignments and mismatch between these two sources, when considering incorporating case study information in a unified notation. From the literature, there is a focus on the three expressions of problem.

3.4.3 Stage 2 data - case study input before- and after the change

Case study data for stage 2 referred to the following case study information:

- What technology change issues the case studies have addressed.
- Descriptions of those context characteristics that enable reasoning about change.

From these descriptions, commonalities were identified for incorporation in the framework. These commonalities represent characteristics of a change context when reasoning about change. They either occurred in all case studies, or, if not in all case studies, were reinforced by

sources from the literature. One example was *replacement.* As a category for a change description, this occurred eight times in the case studies. *Replacement* as a category was also referred to in a discussion on gap typology for evolution requirements (Rolland *et al*., 2004).

Including case study information refined considerations identified in the literature review through the incorporation of:

- detail whilst maintaining the principle of generality; and
- revisions to structures, technique, notation and terminology.

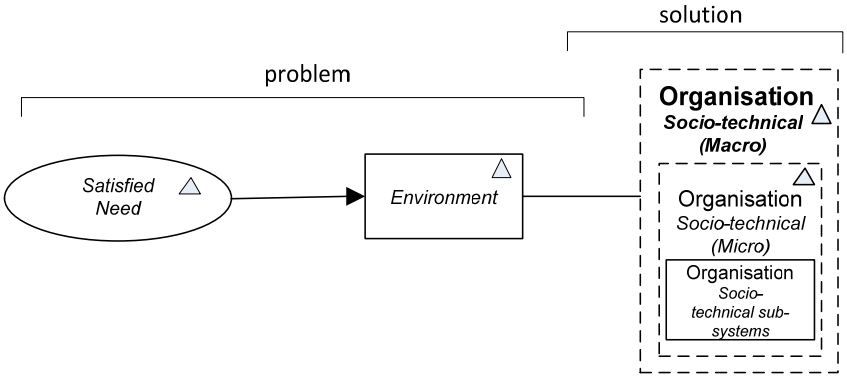


Figure 5 - Before- and after-the-change notation (conceptual framework)

Figure 5 illustrates changes made to the before- and after-the-change notation in figure 4. First, as in figure 4, problem and solution signifiers have been added to clarify where each is located.

Structurally, the three component parts of figure 5 relate to the same location of problem and solution in figure 4. Whilst the central component represents the context in which the problem exists in each diagrams, *Environment* in figure 5 replaces *Context* in figure 4. This reinforces the notion that the problem is located in the environment (Zave and Jackson, 1997), and does not conflict with the use of the word context elsewhere (i.e., change problem context, etc.). *Environment* incorporates both the environment influenced by the organisation, and

environment that influences the organisation. These are referred to as *micro-environment* and *macro-environment* respectively. Micro-environment includes those parts the organisation can influence in a deterministic way (i.e., employees, suppliers, customers), and macro environment includes those parts having a deterministic influence on the organisation (i.e., political, social economic and technology developments). Both notations include an application of adequacy arguments (similar to the previously-described change adequacy argument) and have an emphasis on business process. This reinforces the need to keep in focus the context and its boundaries when reasoning about change.

Other changes have been derived from the 19 case studies and included in figure 5. They provide more detailed socio-technical descriptions than those in the change diagram (figure 4). In each case study, instances were identified of a relationship between different socio-technical levels and/or contexts. For instance, 10 of the studies describe a detailed IT change expressed as a functional requirement at an operation level, but discussed within an overall technology-wide context. To accommodate these more detailed socio-technical descriptions, the dashed box *Organisation* is transformed into three levels in figure 5. The first level, *Organisation/Socio-technical (macro)*, a dashed rectangle in the figure, represents the location and description of the relevant non-IT/IT wider organisation domains of interest. A technology example of this could be an organisation's socio-technical system centred in the Head Office, with a non-IT example being a unit in the Head Office connected to the socio-technical system. *Organisation /Socio-technical (micro)*, a smaller dashed rectangle, identifies the second level to be considered. This reflects the first level descriptions of non-IT/IT activity, but represents a different organisation context. This might be a department in an organisation. The third level, *Organisation/Socio-technical sub-systems* is expressed as a solid line rectangle in the figure, and represents the non-IT/IT sub-systems to be considered. These might be units, or individuals in the department. Incorporating IT/Non-IT descriptions reflects their representation in each of the case studies. For instance, technology change in case studies includes before-the-change descriptions of non-IT activity that after-the-change show converted into IT activity. Adding literature review and case study descriptions provides more information (than figure 4) for reasoning about functional requirement problems, the relationships that exist, and their impact on problem and solution

3.5 Evolution requirements artefact

The evolution requirements artefact represents the third expression of problem in the change problem context. It reflects the approach of Etien and Salinesi. They introduce co-evolution, an alternative to what they describe as the traditionally-produced requirement documents, where evolutions are kept implicit (Etien and Salinesi, 2005). Co-evolution refers to:

> *"…analyses of the reciprocal evolution of systems or software and other entities such as organisations, business processes or environment…"* (Etien and Salinesi, 2005 – p. 1)

The terminology 'evolution requirements artefact' incorporates reference to change impact, change propagation, and the what, where, why and how of change (5WH). To enable comparison between change problem contexts, the three artefacts, *Satisfied Need*, *Environment* and *Organisation*, are the same in the evolution requirements artefact as in the before- and after-the-change artefacts. The additional notation for this artefact is expressed in figure 6.

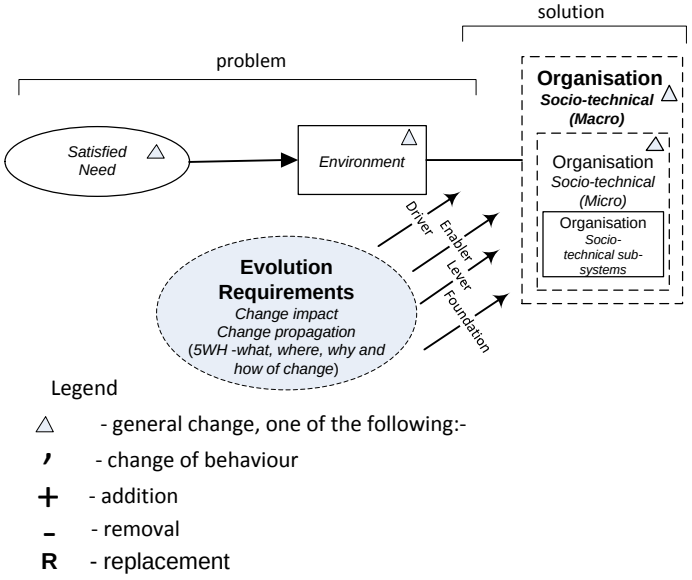


Figure 6 - Evolution requirements (conceptual framework)

3.5.1 Change impact

In figure 6, the legend identifies the five categorises of change impact descriptions: general change, change of behaviour, addition, removal and replacement. The first four of these were drawn from (Brier *et al*., 2006) with *Replacement* derived from (McWhinney, 1992). *Replacement* was identified as a driver for change in eight of the case studies. Legend categories are used to classify change when completing an evolution requirement analysis of before- and after-the-change descriptions. A change impact description is an optative statement of what the change is supposed to achieve. It is related to other parts of the diagram through driver and lever arrows. The driver signifies a current situation as inadequate and needing to be changed; the arrow identifies where the driver comes from. A lever represents the mechanism by which change is realised; the lever arrow identifies where the lever resides. The direction of arrows in figure 6 is for illustration purposes only; noting a correct direction would result from locating them in a real-world organisation.

Adopting a unified notation for the change problem context's three artefacts (i.e., before-the-change, after-the-change, and evolution requirements artefacts) facilitates transforming before-the-change and after-the-change comparisons, into change impact descriptions.

3.5.2 Change propagation (5WH)

Change propagation refers to moving from a before- to an after-the-change situation. Figure 6 includes Evolution Requirements (5WH) where 5WH refers to the what, where (i.e., where macro, where micro), why and how of change. These descriptions facilitate understanding the context in which change takes place. The terminology 5WH is derived from both requirements engineering and organisation development. From requirements engineering:

"…The identification of goals naturally leads to the repeated asking of 'why', 'how' and 'how else' questions..." (Yu. E. and Mylopoulos J., 1998 - p. 1)

From organisation development, knowledge representations of the what, where, why, and how (Skyrme and Amidon, 1997). The detailed descriptions of each component of 5WH also include derivations from the literature, and/or the 19 real-world studies. These are detailed in the following figure 7.

1. *What of change* – a detailed statement of the change
2. *Where of change (macro)* - a general statement that scopes the 'course grain' wider environment within which is situated the organisation's more 'fine grained' change context.
3. *Where of change (micro)* - a statement that scopes the specific, fine-grained, socio-technical organisational change context to be considered.
4. *Why of change* – a statement of the driver(s) representing the force(s) from which change is initiated in the present and/or over time. Incorporates a consideration of (Harker et al., 1993) different origins for change expressed as 6 types of requirements when considering change (i.e., enduring, mutable, emergent, consequential, adaptive, migration).
5. *How of change* – Lever, enabler and foundation statements (Skyrme, 2002, Standards Australia, 2003) inform change implementation in the present and/or over time. Incorporates a consideration of Stacey's control and flexibility approach (Stacey, 1990) expressed as classifications of *closed, open* and *contained* change.
    - *Enablers* - descriptions that provide support for change, covering the areas of structure, culture and the environment.

- *Lever* – a statement of the action through which change is realised covering processes, implicit and explicit knowledge**,** measures, (business) hubs and centres, and market leverage.

- *Foundations* – represent the combination of hard and soft infrastructure tools and techniques that determine the ultimate capacity and capability of an entity to deploy change.

Figure 7 – Change propagation (5WH)

In the figure, the *what* of change requires a description of what is changing? The *where (macro)* and *where (micro)* were represented in each of the 19 case studies. They facilitate both general and more detailed descriptions respectively, of related locations in which change takes place. For instance, *where (macro)* could be the wider external environment in which organisation change is experienced (e.g., subsidiaries, competitors etc), and *where (micro)* could be its physical location in the organisation. Alternatively, the *where (macro)* could be a legacy description, with *where (micro),* a description in the present.

The *why of change* refers to *drivers* of change in a context of *the present* and *over time*. There are *lever, enabler* and *foundation* descriptions in the *How of change*. These are also reasoned about in the context of *the present* and/or *over time*.

Change propagation descriptions add to impact analysis descriptions. The first four designations (i.e., the what, where (macro), where (micro), why of change) provide information for *problem analysis* related to an existing situation when considering change propagation. They facilitate reasoning about relationships related to what change is, where it occurs and why. The how of change, the fifth designation, facilitates problem analysis descriptions that affect change propagation (i.e., moving from the before to the after the change situation). Etien and Salinesi's reference to the relationship between 'what of change' (i.e., functional requirement) and 'why of change' (i.e., evolution requirement) is extended by the framework's inclusion of 'how of change' (i.e., levers, enablers, foundations).

Change propagation descriptions can be obtained from the socio-technical system, the system's organisation environment, or the wider environment in which the organisation operates. This is dependent on the task, technology and/or people focus provided by stakeholder/users. For instance, descriptions could have a technical and/or human origin, and be sourced from requirements engineering and/or organisation development.

3.6 Summary

In bringing together the previous sections the following summary describes one application of the approach. It confirms support from the literature where appropriate. An early stage contact with stakeholder/users is assumed once an idea for a solution has been identified. The client/customer determines the scope of the approach and focus for discussions, such as the level of generality. Alternative sources for reference include third-party involvement in the reasoning process, for example from requirements engineers or business analysts.

Reasoning about the change problem context aims at ultimately identifying subjects for design. It is based on the three change context techniques referred to in Foundations from the literature (3.1.1). These are summarised as reasoning about before and after-the-change situations (Franken and Janssen, 1998; Zowghi and Gervasi, 2004; Roland *et al*, 2004; Etien and Salinesi, 2005); reasoning about Non IT/IT activity (Robertson & Robertson 2006), and separating solution from problem when reasoning (Jackson, 2001).Whilst the method of reasoning would be determined according to organisation needs we refer to the notion of the 'generative dance' (Cook and Brown, 1999). Our adaptation of this refers to reasoning that considers different perspectives. We suggest two examples. The first, reasoning that moves between the general, (broader perspectives), and the particular, more detailed perspectives. Second, considering the problem with the solution in mind, and considering the solution with the problem in mind. Both refer to chapter 2 and the reflection approach (Schon D.,1983; Kolb and Fry, 1975), and the consideration of overarching contexts in tandem with more detailed

contexts. A level of generality (Gunter *et al.*, 2000 – pp. 37-38) is selected by the client/customer with a balance of control and flexibility (Stacey, 1990), appropriate to the sense-making needs (Weick, 1995) of the organisation's context of application (Gibbons *et al.*, 1994). Scoping the business process incorporates describing its relationship to the outside world (Robertson and Robertson, 2006 – p. 70) with subjects sourced from the socio-technical system (Mate *et al.*, 2005). All descriptions represent the material observable effects (Jackson, 2001 - p. xiii). Agreement is reached on the extent to which open, closed, and contained change classification (Stacey, 1990) is included in the reasoning process. Using the three artefact structure of the change problem context, preliminary before-the-change and after-the-change descriptions consider problems related to requirements evolution (e.g., identifying what change will be). Reasoning about after-the-change descriptions is founded on before-the-change descriptions. Completing retrospectives (Robertson and Robertson, 2006, p. 360) provides the opportunity to interrogate before-the-change situations For instance asking questions about existing task, technology and people activity and contributions made by non-IT/IT activity. The before-the-change descriptions provide intelligence on existing alignments and dependencies in the business process. For instance: What works well? What might be improved? What might be automated? (Robertson and Robertson, 2006, p. 31). Before-the-change information can then be considered for incorporation by the after-the-change situation in a systematic way, facilitated by the unified notation of the framework. 'Maybe models' can represent stages of the reasoning process when determining after-the-change opportunities (Mathisen *et al.*, 2009). Evolution requirement descriptions follow. These incorporate change propagation and identify dependencies between artefacts (Etien and Salinesi, 2005). Change impact descriptions can be sourced using the terminology gaps and similarities (Rolland *et al.*, 2004). A mismatch-free, alignments-maintained, initial change adequacy argument is completed that links together before-the-change, after-the-change and evolution requirement descriptions. An initial argument provides a reference point during the reasoning process. This facilitates a continuous monitoring of changing relationships between artefacts and their alignment. The argument aims to represent a consistent, complete and correct business process (Zowghi and Gervasi, 2004). The process of reasoning that follows refers to the earlier explanation of a generative dance, a series of

iterations, between the initial change adequacy argument, and the developing before-, after-the-change, and evolution requirement descriptions. A final change adequacy argument is addressed to conclude the reasoning process and confirm a changed, but coherent, business process.

When reasoning about variables, breakdowns or misfits can occur. These are resolved by reference to the client/customer. For instance, one might consult the client/customer when speculating about non-functional requirements or descriptions with no related observable behaviour to the subject being considered (e.g., laws, regulations). Completing an adequacy argument mitigates misfits by bringing together discussions of each variable. This ensures business process coherence when reasoning takes place.

Applying the approach does not result in the identification of correct requirements. At the end of the reasoning process, stakeholder/users have experienced a process of change through a 'learning-by-doing' event (Schon, 1983). Subjects for design are identified, a familiarity of the changing process is experienced, and a consequent understanding of change is achieved.

3.7 Conceptual framework/case study fit

In considering the fit between the conceptual framework and the case studies, the following questions informed the extent to which the framework could be applied to case studies. Whilst case study information contributes detail in the framework (e.g., more detailed notation), case studies provide a useful check on the overall fit between them and the framework. The questions we asked of the case studies were based on identifying what information they had that would enable the framework to represent their situation. Responses came from case study numbers in Tables 2 and 3, which are cross-referenced with column referencing, A-S.

First Question on 19 case studies:

Q1) **Does the framework fit; can each of the organisation high-level contexts be captured?**

For the framework to be applicable there needs to be case study descriptions that represent a

technology change in an organisation process. The process has to be triggered in the context of, and with reference to, a 'need for service' that is met by an organisation's 'provision of service'. All case studies met this need.

Examples of relevant data: Column A - which describes the subject of change, and column N - its contribution to business process.

Second Question on 19 case studies:

Q2) **To what extent could the approach describe the context of a case study?**

There are 19 information columns in tables 1 and 2. Each has a heading which refers to an aspect of context when describing case study technology change. The framework includes explicit descriptions. These require subjective responses from the organisation's stakeholder/users. All case studies provided subjective responses. There are a number of examples in Figure 7, Evolution Requirements: 'Satisfied Need' is informed by column D (Quality, Cost, Delivery); the explicit description 'Environment', by column C, (Organisation-wide and/or Subsidiary); the explicit description 'Organisation Socio-technical macro', by column I, (scale of change); and the explicit description 'Socio-technical sub-systems', by column N, (Business Process) and column L (level of granularity).

The following sub-questions considered the appropriateness of the approach embodied in the frameworks:

Q2a) **What level of detail is accommodated in the case studies?**

The level of detail described was uneven. Although, in Question 2, examples of columns referring to context of service, included column N and its description of Business Process, and column D, referring to quality, cost and/or delivery of service. For Case Studies 1, 2 and 4 there was no description for column O (i.e., Business Services).

Q2b) **What detail fits readily?**

Details that fit readily related to descriptions of technology that referred to observable behaviour and effect descriptions of a changing context. These were related to need for service, provision for service, and satisfaction of service.

Examples of relevant data: columns - A (subject of change) - S (evolution evident)

Q2c) **What detail could *not* readily be accommodated**.

Detail that could not readily be accommodated related to non-functional requirements (i.e., when there is not an observable behaviour and effect description of provision of service) and technical specifications (e.g., not appropriate for understanding by all stakeholders).

Applying this question indicated unevenness across case study descriptions which potentially impeded the identification of commonalities. A consequence of this was a potential omission of relevant descriptions in the framework, the inclusion of which would trigger responses to change by related organisations.

Relevant data examples: columns - C (Organisation-wide and/or subsidiary), column G (Change type); column H (Level of change).

Q2d) **What common elements have been incorporated?**

Commonalities were identified whose representation as explicit descriptions in the framework (i.e., requiring subjective response from organisation) would not compromise the level of generality of the approach (i.e., ability to be applied to a wide variety of organisations). As a result, commonalities have been included which, as notational structures and descriptions, alert stakeholders to potential subjects for their consideration.

Relevant data example: These are referred to in Case study input - before- and after-the-change (3.4.3) and Evolution requirements (3.5). An example of relationships identified between different socio-technical levels and/or contexts refers to columns C/G/H. 12 of the studies describe a detailed IT change, expressed as a functional requirement at an operation level (column G/H), but discussed within an overall organisation-wide technology context (column C)

The structures, techniques, notation and terminology used in the framework have been derived from the literature. Comparing framework information with the real-world contexts of 19 case studies, enabled identification of relationships between the two, confirmed aspects of the notation, reflected and mirrored some of the terminology used, and contributed some additional notation. The frameworks high-level of generality was sufficient to accommodate each case study. The framework's three areas of concern (i.e., organisation, environment, and satisfied need) could be represented by information from each case study.

3.8 Conclusions

At the outset of this chapter, the following aim was identified: In an organisation brown-field context, how can changing requirements be represented, to facilitate identifying problems, and reasoning about how change should be realised?

This aim reflected recognition of the increasingly complex contexts in which change has to be realised. The conceptual framework is our response. It unifies the complexity of a context before-a-change, with its realisation after-the-change.

The literature identifies requirements engineering as a development process that spans the gap between the informal world of the stakeholder, and the formal world of software behaviour (Nuseibeh and Easterbrook, 2000, p. 2). The framework, applied in the early stages of the requirements elicitation process, helps stakeholders to both start and progress their journey across this development gap.

The relevance of the framework is based on its appropriateness, its ability to address problems identified in the literature review. Needs from the past, the present, and the future, were identified. These have been accommodated in a unified approach which distinguishes the framework in a number of ways.

The focus of the framework is on organisational change, and consequent re-alignment of socio-technical systems in business processes. Change problems and subjects for design are

identified through stakeholder/user reasoning about the implications of change, and how change should be realised.

The framework's application is centred on three expressions of change problem analysis. These are scoped by reference to recurring subjects of change described in chapter 2, and reflected in Foundations from the literature (3.1.1). Stakeholder engagement, alignment and mismatch of relationships, change over time, and problem analysis, have been recurring subjects of change since 1990**.** Combining recurring subjects with problem analysis techniques informed the representation of the framework. Stakeholder/users are the focus for its application.

Three expressions of change problem facilitate change analysis, and the consequent identification of subjects for design. First, separating solution space from problem space (Jackson, 2001) allows for a separation of concerns between an organisation, its context and satisfied need. This assists the separation of concerns when analysing task, technology and people relationships in business process. Expressing before and after-the-change situations in a unified notation provides the context for analysis. Before-the-change subjects for design can be discovered by identifying the essence of the problem, the underlying problem to be resolved (Robertson and Robertson 2006). Also, a reflective approach (Schon D., 1983) can evaluate an existing business process by studying the role of task, technology and people (e.g., what might be improved in non-IT/IT activity, etc.). Before- and after-the-change descriptions can also be compared. Problems can be identified related to change impact and change propagation (Etien and Salinesi, 2005). Comparisons inform what needs to be designed when moving from a current to a changed business situation.

Using this problem-centred approach to identify subjects for design supports transforming organisation-wide change descriptions, into detailed descriptions of alignments and mismatches of task, technology and people. Separating need for service from provider of service, and considering the social, the technical, and the task parts of a business process, make it possible to reason about changes which go beyond technology. Identifying subjects for design can have a consequent impact on domain and interface descriptions, non-IT/IT relationships, and alignments and mismatch when changing technology.

Maintaining business process coherence when stakeholder/users reason about change requires the application of adequacy arguments. There are other constraints on the reasoning process. Stakeholder/user reasoning is grounded with descriptions of observable behaviour and/or effects. This increases the potential for agreement amongst stakeholder/users. There is a reduction of more subjective opinion, and a use of refutable description. Reference to stakeholder/users also incorporates the resolution of inadequacies, and/or disagreements on subject matter (e.g.: the selection of domains to reason about, the level of complexity to be considered, etc) when scoping and focusing ways forward.

Flexibility is a factor in supporting engagement with stakeholder/users, and accessing the multiple contexts they represent. This is applied in a number of ways. The approach can be applied to different organisation contexts. This stretches from organisation-wide applications (i.e., incorporates subsidiaries, departments, teams etc.), to applications by individuals. An individual employee's contribution to a business process could be the subject of analysis using the framework. The employee would be engaged in describing their contribution in the business process, differentiating between IT and non-IT activity, commenting on what works well, not so well and what might be improved, and recording and communicating on-going views in the present and over time.

Flexibility is also expressed in the framework's level of generality. This combines Stacey's terminology of control and flexibility (Stacey, 1990). Control represents explicit descriptions in the framework (i.e., as determined by client/customer), flexibility, subjective responses from stakeholder/users. Whilst maintaining basic structures, techniques, notation and terminology, the balance of control and flexibility can change to reflect particular organization / stakeholder / user circumstances. These may include developments in the wider political, environment, social and technology sectors. The control and flexibility relationship signifies the agility of the approach. An appropriate process or parts of a process can be selected to meet particular needs of an organisation (Robertson and Robertson, 2006). As in Jackson's approach, the framework is not:

> *"….describing a fixed method or a tightly controlled process…"* (Jackson, 2001 - p. 47)

Additionally, the flexibility in the framework facilitates its application to what has been referred to as a single static step approach to requirements (Harker *et al*., 1993). The sequence of before-the-change and after-the-change artefacts followed by the evolution requirement artefact can also be applied to the more fluid approach. This is referred to as a continuous representation of the evolution process over time.

> *"…The evolution of an information system should be a continuous process rather than a single step…"* (CAiSE, 2010 - p. 1*)*

This fluidity also facilitates third party involvement. Requirements and/or business analysts can bring different perspectives to the reasoning process. They can be the source of adaptations to the approach in the present and over time, provide updates on current practice, and be a catalyst for encouraging progress and/or change, for instance, when introducing new ideas for stakeholder/user engagement.

Situations in which the framework can be applied include legacy situations, current situations and/or continuing changing situations. Legacy information may be accessed through contact with stakeholder/users, and/or retrieved from recorded information. An understanding of a previous change situation may be required before embarking on understanding a present situation. There may be a need to facilitate traceability, and/or alignment of task, technology and people from the past, that incorporates tracking in the present. A changing situation over time can be represented by an on-going approach to identifying problems of automation. For example, applying retrospectives provides improvements in process (Robertson and Robertson, 2006)

The conceptual framework has potential for representation as a pattern, and consequent use as a reference model. For instance, when adapting an existing level of generality to represent a bespoke part of an organisation, an organisation and/or organisation sector. An application in one part of an organisation can represent a recurring change in another part of the organisation.

This aspect of the approach aims at supporting a process of synthesis through the codification of recurrent patterns of organisational change. (The change frame is proposed in chapter 5 for the capture of such patterns, an example of which is presented in chapters 5 and 6).

The approach is an analytic tool; it is not a panacea. For instance, it would not be sufficient for managing the project, or making the business case, each of which could require descriptions that go beyond observable behaviour and effects. The approach requires engagement with stakeholder/users, but it does not focus on *how to engage* stakeholder/users. Also, it does not provide a requirements elicitation answer or correct requirements, but rather, a knowledge and understanding of the changing non-IT/IT requirements context.

While selected for application to a wide variety of organisations, the level of generality is context specific. What has been introduced in this chapter is a level of generality that is derived from the 19 case studies and that is sufficient to address issues of interest in them. Unfortunately, the case studies are 'locked in history', as there are no forward citations concerning how those cases developed, and so we have no confirmation in other contexts. However, the 19 case studies are arguably representative of technology change in business; it is a matter for future work to validate this empirically. Moreover, the framework has the flexibility to adapt to focus at a different level of generality, should an organisation want to do so. Again, validating this empirically by taking the framework into the field is a matter for future work.

Overall, the approach facilitates the analysis of changing technology in organisations; supports the identification of requirements evolution and evolution requirements; alignments with context; coherence when business change takes place; and, through the identification of patterns of recurring change contexts, the development of context aware and re-usable artefacts. Experience gained using the approach, also facilitates the application of codified wisdom for reasoning about new change problems, in an on-going approach to changing technology**.** Applying the approach supports our response to the thesis objective. It facilitates an understanding of change, through client/customer and stakeholder/users experiencing a process of change.

Chapter 4. Reasoning about the Change Problem Context: A Real-World Example

This chapter aims to show how the conceptual framework is relevant and useful when considering change problems in an organisation real-world brown-field setting. Chapter 3 presented the potential of the framework; this chapter illustrates the application of the structures, techniques, notation and terminology embodied in the framework to a real-world situation. This chapter illustrates a response to the three research intentions identified at the start of chapter 3. First, it identifies relevant change subjects with an adaptable approach that supports accommodating a variety of organisation situations. Second, it combines structures, techniques, notation and terminology that can help developers to engage with client/customers and stakeholder/users. Third, it uses an approach for identifying patterns that provides a predictable response to a recurring change problem.

The example is a real-world legacy situation, based on previously recorded information. It is a simplified context with a focus on information system applications that consider the addition of an intranet. The simplicity of the change being considered enables a thorough analysis of framework fundamentals and incorporates structures, techniques, notation and terminology that express the following.

- A systematic problem-based, context-aware approach to reasoning about non-IT/IT activity.
- The representation of the complex change problem context in which the organisation operates,

- The expression within a unified notation, of before-the-change, after-the-change and evolution requirement artefacts, their interactions and relationships.
- A separation of environment from system to distinguish relationships between them. Subjects for design are identified with descriptions of material observable effects the system should bring about.
- Descriptions of client/customer focused tasks, technology and people, distinguishing relationships between them and business process.
- Adequacy arguments that resolve idiosyncrasies when reasoning, through the need to align business process change affecting task, technology and people.

4.1 Introduction

The case study approach provided, within the research programme timescale, the essential information required to show how the framework is applied. Conducting *in situ* empirical studies in companies in order to gather detailed accounts of change was also considered, but timescale and access constraints made such an approach infeasible. It is also left for future work to conduct evaluative field studies of the 'live' application of the framework

This first case study deliberately avoids the complexity of multiple views of the organisational setting, in order to provide a clear illustration. This strategy is informed by Jackson's example, in which he omits information in order to facilitate simplification of illustration, (Jackson, 2001 - p. 9):

> *"…Remember that you must explore the context and the requirements iteratively. We're not showing the iteration explicitly: it would make for rather tedious reading…"* (Jackson, 2001 - p. 47)

Jackson describes an example noting that requirements are simple, interfaces are simple, and roles played by domains are simple, but,

> *"…these still require careful analysis…..they can raise many concerns and difficulties…"* (Jackson, 2001 - p. 54)

Jackson states:

> *"…we won't go further into the world than is necessary to demonstrate the capture and analysis of the purposes of the notional customer…"* (Jackson, 2001 - p. 16)

Whilst the published material offers no evidence that a client/ customer focused approach was used to write the case study, its descriptions are scoped by content made available by the organisation, and by the choices made by the case study author. From this information, authored text is selected to represent client/customer and stakeholder/user descriptions. Where appropriate, for illustration only, additional information is provided that was not included in the case study, such as the description of the scenario used to introduce the approach. The business process subject is information systems. These are focused on communications with External Services. The technology change is the addition of a computer network where a network did not previously exist. The organisation is the City of Tampere (Finland).

4.2 A real-world example (the City of Tampere Finland)

The example represents a genuine real-world brown-field situation (Anttiroika, 2004). The City of Tampere (Finland), with its program for citizen-centred local e-government, has developed its information networks since the 1980's. Through the development of the internet, the City has recognised the potential for making information more readily available to its

citizens. The example, the addition of an internal computer network is a communication change implemented by the City in developing its information network program.

We adopt the following scenario. The City of Tampere is reviewing its approach to evolution of requirements. Should it be a static, single-step approach, or a continuous process in which evolution is an inherent property of the system? The City is interested in a problem-centred approach and has requested that a previous case study on technology change (i.e., a legacy example) be used to illustrate the application of the framework. It would like the following to be included:

- Scoping, describing and analysing the change problem context.
- Adapting a current situation to the change required through an identification of those existing parts of a situation affected by the change.

Whilst this legacy example is being used here to illustrate the application of the framework, in a real-world situation stakeholder/users would be involved. For instance, stakeholder/users could use the framework as an introductory approach in preparation for empirical applications across the organisation.

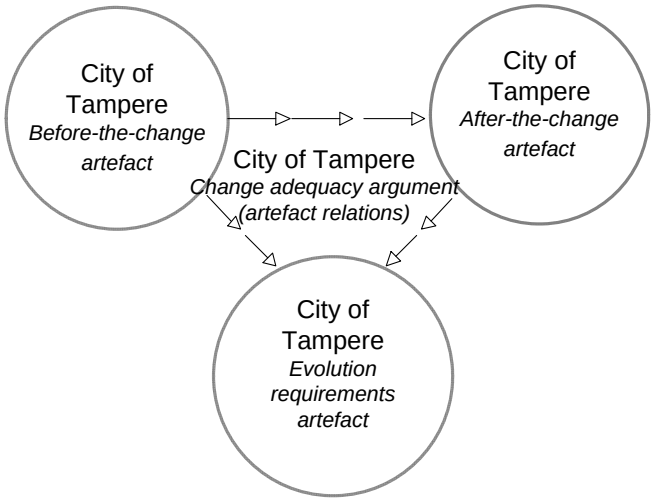


Figure 8 - Change problem context - City of Tampere

Figure 8 indicates the three major analysis steps, each reflected by an artefact. The first step characterises before-the-change, when the City deployed technology mainly in internal administrative processes. These included word processing, payroll administration and

accounting (Anttiroika, 2004 - p. 374). The second step describes after-the-change, and the City's need to install an internal computer network to link the City's administrative processes to city, local universities and local telephone operations (Anttiroika, 2004 - p. 374). The third step compares before- and after-the-change descriptions, to describe evolution requirements.

The change adequacy argument in the figure represents a mismatch-free, alignments-maintained business process. Making the argument ensures that reasoning about change in each artefact maintains a coherent business process. It aims at maintaining relationships between variables that are a consistent, complete and correct expression of the City's business process.

Completing these three steps provides descriptions of the change problem context. Together they represent an adaptation of a current situation to the change required, and an identification of those parts of an existing situation affected by change.

4.3 First step - before- the- change descriptions

The first step of the analysis is to characterise the context before the change. Issues considered include existing non-IT/IT relationships (e.g., what might be automated, etc.), and separating problem and solution descriptions in order to clarify relationships between them.

Figure 9 is an echo of Figure 5. It is included here as a reminder of the notation used for these descriptions. The 'satisfied need' is the goal to be realised by the socio-technical change in the 'environment' or broad organisational context. Hence, the goal and context together characterise the problem focus. Environment also relates to 'organisation', to the specific organisational context: the domains of the organisation which are involved in or affected by the change. Hence environment and organisation together characterise the solution space.

Figure 10 characterises the City of Tampere within this notation, with extra speech bubbles to provide the interpretation of the diagram elements. The 'satisfied need' or goal of the change is the provision of administrative services to the community. This is summarised in the label C*ity Administration Service*. The environment' is a set of interacting agencies which provide services to the City community (i.e., city services, local universities and local telephone

operations). All agencies or service providers are summarised as *External Services*. These external services interact with, but are not electronically networked to, the organisation, which is the *City of Tampere.* To reiterate: the need currently satisfied by the City of Tampere is the provision of administrative services to the community, so that, when External Services require a service, an appropriate service is provided by the City.

The before-the-change solution to satisfying this need is represented on the right-hand side of the diagram. The socio-technical macro level is comprised of *City Departments (Non-IT).* This domain is an abstraction of internal departments receiving requests from *External Services.*

The socio-technical micro level represents the specific socio-technical sub-systems that provide the relevant services and are the focus of the change. The micro level comprises:

- IT (all the computerized administrative systems),
- IT Operator - all administrative staff interfacing with IT,
- Archive (all non-electronic administrative systems).

Figure 10 details the interactions between the domains described (each represented as a diagram element), by labelling the domain interfaces (i.e., the arcs between diagram elements), using acronyms for the elements of the environment initiating an action, and codes for the actions or phenomena. For example, ES!a denotes that *External Services* requires a service (action 'a'). Similarly, CS!x denotes that *City Departments* provides a service (action 'x'). The key to figure 10 identifies the actions or phenomena at each domain interface and their associated codes.

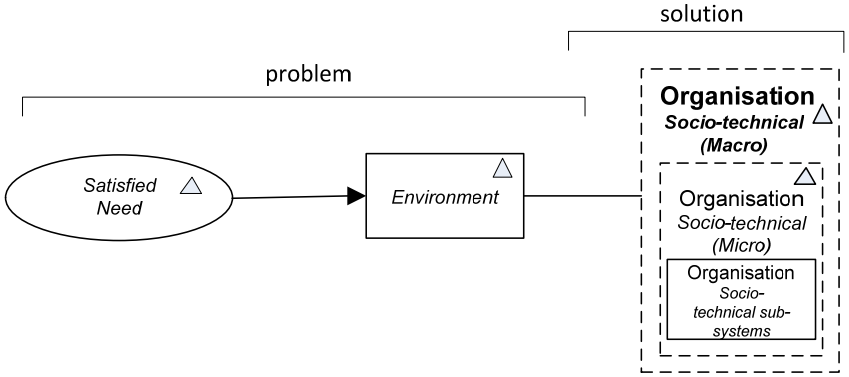
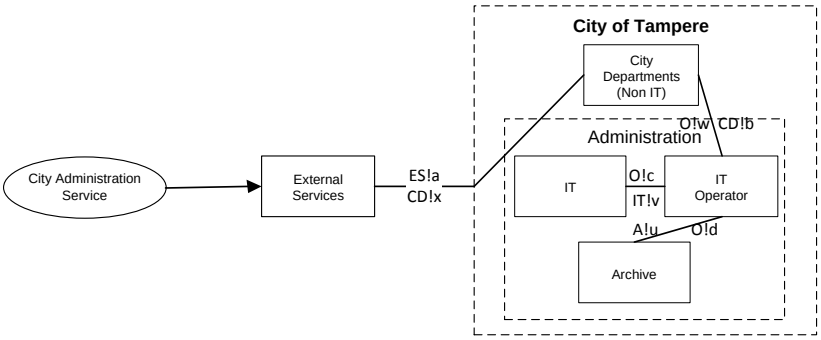


Figure 9- Notation for change – from the conceptual framework



a	*require service*	u	*provide non-electronic information*
b	*forward request*	v	*provide electronic information*
c	*access IT*	w	*provide information*
d	*access Archive*	x	*provide service*

(adapted from Brier *et al*., 2006)

Figure 10 - Before the change – City of Tampere

As it was not reported whether a problem-centred approach was used in the original development, there is no explicit justification for the correctness of the before-the-change diagram and its descriptions. However, having reverse-engineered from the case study the essential parts of *External Services*, *City of Tampere* and *City Administration Service*, a plausible corresponding adequacy argument can be articulated. The adequacy argument resolves client/customer and stakeholder/user speculations, about the scope and descriptions to be included in achieving mismatch-free alignments in business process. One argument, involving all given descriptions and phenomena is:

> When External Services *require service*, then the City Department (Non-IT) *forwards the request* to the IT Operator, who, depending on the request, *accesses IT* or *accesses Archive*, or both, in order to access *electronic information* and *non-electronic information*, then *provide information* to the City Department (Non-IT) that *provides service* to External Services, hence satisfying the need.

4.3.1 Problem analysis

The before-the change artefact represents the problem analysis using the framework's structures, techniques, notation and terminology. The first expression of the problem (i.e., changing existing non-IT/IT activity) provides the opportunity to query what may or may not be automated when adding a network. The potential for automation can be considered by identifying the essence of the problem new technology is meant to resolve (Robertson and Robertson 2006). As the problem analysis was not reported in the case study, we suggest an example: to analyse the context of the information systems process, with the aim of identifying what initiates the need for information. This requires eliciting descriptions from the City of Tampere's *External Services*: the city services, local universities and local telephone operations which initiate requests for information. A number of questions could be asked. What is it that triggers the need for employees to request information, when does it happen, where are employees when it happens? Reasoning about triggers in these different locations could impact on task, technology and/or people design, such as re-scoping where access to automation is made available.

The before-the-change artefact refers to three variables. These are the domains described as *City Administration Services, External Services* and *City of Tampere*. Reasoning about change can concentrate on describing the present, and/or be more analytical, for example by evaluating lessons learned when considering existing non-IT/IT activity (Robertson and Robertson 2006). The following two variables provide examples.

External services, its interfaces, and shared phenomena, represent three domains; citizen services, local universities and local telephone operations. These indicate the parts of the world where the change problem resides. Detailed consideration of each domain could reason about task, technology, people activity when *requiring service* (phenomena ES!a). For instance, what task is completed, who completes the task, is technology used. In considering relationships (e.g., alignments and mismatch) in each domain, and between domains, one can reason about synergies between domains in this *'requiring service'* aspect of the business process. External

Services provides the focus for grounding descriptions in the reality of the environment where the problem resides. Its domain properties bridge the gap between the provider of the service (*City of Tampere*) and the satisfied need (*City Administration Service*) that interests the client/customer.

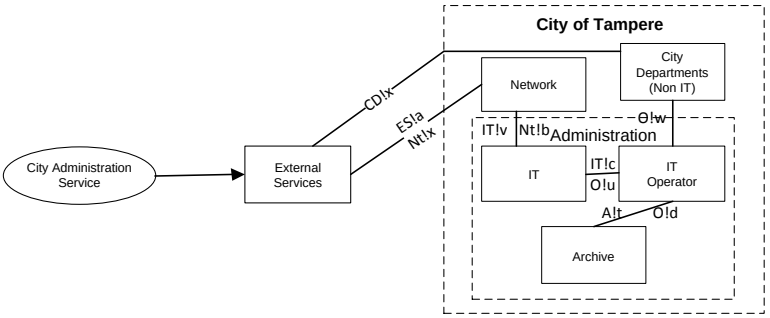
The *City of Tampere's* business process relationships, and the existence of alignments and potential mismatches, are represented by interface descriptions linking *City Departments* (Non-IT), *IT Operator*, *IT*, and *Archive*. As the provider of a service, *IT Operator* forwards requests from City Departments (CD!b) and in turn requires *access IT* (O!c) of the IT domain, *access archive* (O!d) of the Archive domain, and *provides information* (O!w) to *City Departments*. Reasoning about these activities determines which aspects can be automated when changing technology. It also illustrates how IT Operator is not just a user of IT. As a *people* component in the task/technology service provision, IT Operator will be required to follow certain procedures when accessing Archive, and/or accessing IT, and/or providing information. Changes made will have an impact on these procedures, illustrating how IT Operator can be the subject of design.

An understanding of the problem context has been facilitated by separating description of the problem (where the need for change exists, i.e., *External Services* and *City Administration Service*) from description of the solution (where the solution resides, *City of Tampere*). Distinguishing between task, technology and people, can facilitate identifying subjects of design when automating business processes.

4.4 Second Step - after- the- change descriptions

The second step characterises the socio-technical system after the change, in this case adding a computer network to the City's information system. The *after-the-change* artifact facilitates reasoning about functional requirements, using the same notation as the *before-the-change* artifact. Figure 11 represents the socio-technical system after-the-change. The new domain *Network* is in the right-hand side of the diagram. *Network* represents the new IT addition within

City. External Services have direct electronic access to *Network,* with consequent changes to their domain interfaces and shared phenomena. Within the City's *Administration*, *IT Operator* receives requests via the *Network*, for electronic and non-electronic information.



a	*require service electronically*	t	*provide non-electronic information*
b	*forward electronic request*	u	*access IT*
c	*alert IT Operator electronic information*	v	*provide electronic information*
d	*access archive*	w	*provide non-electronic information*
		x	*provide service*

(adapted from Brier *et al*., 2006)

Figure 11 - After the change – City of Tampere

In this after-the-change situation, the socio-technical system still satisfies the same need to give access to *External Services* to *City of Tampere* information system. However, the service is now improved through the provision of electronic access, which makes information more readily available. A new adequacy argument reflecting the addition of a network and change in the City of Tampere's processes is expressed as follows:

When External Services *requires service electronically* through Network, then IT *alerts* IT Operator, who, depending on the request, *accesses IT* or *accesses archive*, or both, in order to *access electronic information* and *non-electronic information*; then, depending on the nature of

the information, IT Operator *provides non-electronic information* to City Departments (Non-IT), which *provide service* to External Services, and/or IT *provides electronic information* to Network, which *provides service* to External Services, hence satisfying the need.

4.4.1 Problem analysis

Adding the Network domain is represented in differences between the before-the-change and after-the-change artefacts. There is now an IT connection from *External Services* to *IT* domain and *IT Operator* domain (represented as interface phenomena ES!a, NT!b, IT!c).

Reasoning about after-the-change artefact includes both problem-centred analysis (i.e., considering the character of the problem before considering solutions) and considering changing existing non-IT/IT activity (i.e., what might be automated when adding a network). In the discussion of the before-the-change artefact, it was suggested that identifying the triggers for using a business process in *External Services* could reveal automation opportunities when changing technology. One example is posting automatic updates on *External Services* home pages, in order to reduce the need for some *require service* requests regarding updates from personnel to *IT Operator.*

Use of the same structures, notation and terminology in the before-and after-the-change artefacts facilitates comparison between the two, and identification of differences. For instance, in the before-the-change artefact, it was suggested that procedures followed by *IT Operator* could change when accessing Archive, accessing IT and/or providing information. In *after-the-change*, there are changes to the interface phenomena between IT Operator and IT, requiring procedural changes by IT Operator. IT Operator is now activated electronically (IT!c), with access and information being provided electronically. Both the home page and procedure examples represent additional automated activity; a change in alignments of task, technology and people; and changing relations between non-IT/IT activities in the City's business process.

Changes in behaviour and/or a need for additional skill sets could require training for *IT Operator*, and/or staff, in the domains represented by *External Services* (i.e., *citizen services,*

local universities and *local telephone operations*). This is an example of change impact, which is incorporated in the next step, within the subject of evolution requirements.

4.5 Third step - evolution requirement descriptions

Whilst the third step includes further reasoning about non-IT/IT relationships (i.e., what might be automated when adding a network) the focus is on problems related to change impact (i.e., those parts affected by change) and change propagation (i.e., moving from a before- to an after-the- change situation). This is the framework's third expression of the problem.

4.5.1 Change impact

Figure 12 repeats Figure 6 as a reminder of the notation used for evolution requirements. The figure is included to aid understanding of the origin of change impact descriptions.

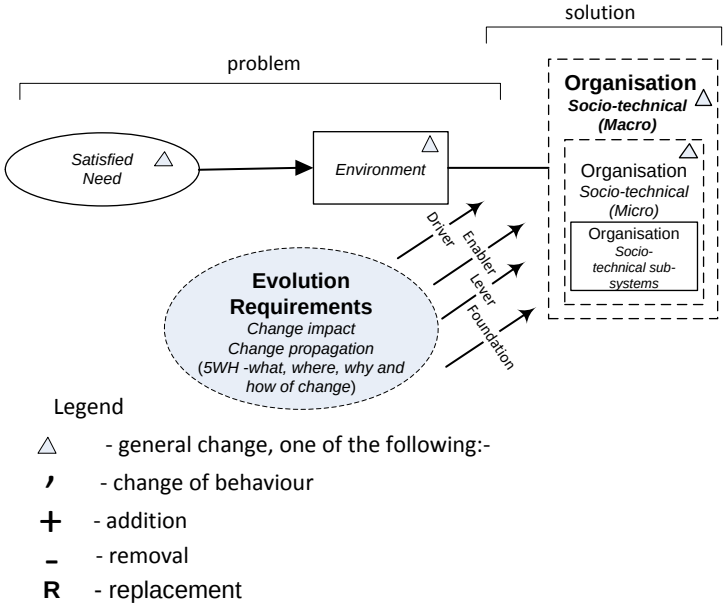
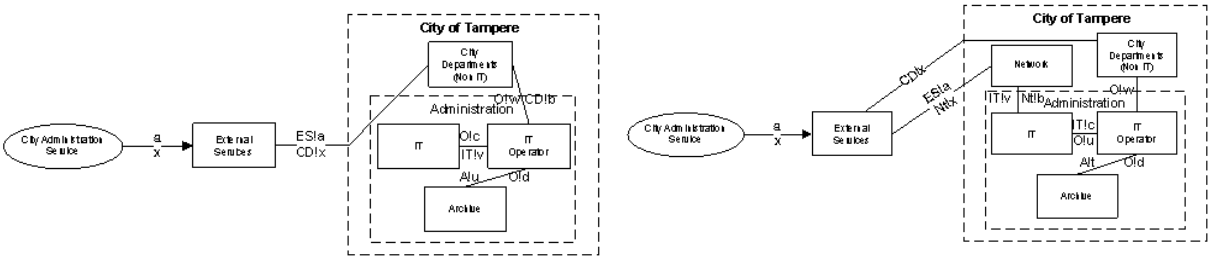


Figure 12 - Evolution requirements notation – from the conceptual framework

The analysis of change in this example has followed the analysis process outlined in chapter 3. First, before-the-change descriptions were obtained and descriptions of *City of Tampere*, *External Services* and *City Administration Services* were separated. Second, after-the-change descriptions were obtained which maintained the same separation of the three variables. Third, a comparison of the two identified where change occurred and each type of change. For convenience, the before-the-change and after-the-change descriptions presented earlier are juxtaposed in Figure 13. Change impact descriptions can be compared in figure 14.



Before-the-change descriptions (Copy of figure 10)

After-the-change descriptions (Copy of figure 11)

Figure 13 – For comparing before-and after-the-change - City of Tampere

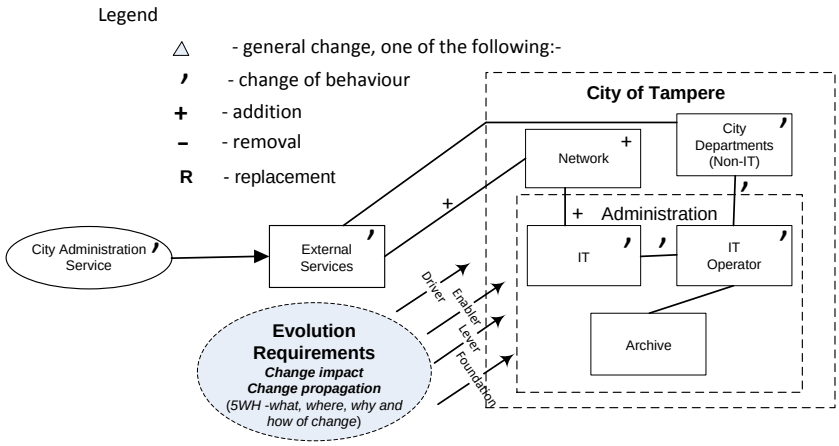


Figure 14- Change impact descriptions – City of Tampere

Figure 14, the change impact description shows that the *Network* domain and its interface with both *External Services* and *IT* have been *added*. This is indicated with the plus sign in the Network rectangle. Reasoning about the *addition* of a domain or interface may identify other potential changes, such as consequences on task, technology, and people relationships, in the existing before-the-change business process. Hence, the categories captured in the legend in figures 12 and 14 can be used to drive an analysis of change impact. For instance, a change of behaviour may be required in City of Tampere that affects *IT Operator*, *IT*, *City Departments (Non-IT)* and its interface with *IT Operator*. This initial expression of the effects of change, suggests that more detailed interrogation is required of the domains concerned. Where the opportunity for this is not readily available (i.e., as in this legacy case study) further discussion with client/customer can consider what information may be required.

4.5.1.1 Problem Analysis

A comparative analysis of before-the-change and after-the-change descriptions can identify where change may affect the internal consistency of the business process. Using the legend categories (figures 12 and 14) to prompt discussion, facilitates reasoning about observable behaviours and effects. In figure 14, potential changes of behaviour have been identified in the domains *City Departments (Non-IT)*, *IT Operator*, and *IT*, and at interfaces (e.g., between *City Departments (Non-IT)* and *IT Operator*, and between *IT Operator* and *IT*). Identifying potential changes of behaviour requires further reasoning to locate and describe how they are expressed in the business process. One example was detailed earlier in after-the-change descriptions of IT Operator/IT interface. Automation at this interface has required changes in procedures carried out by IT Operator. This illustrates how the approach identifies subjects for design.

Referring to dependencies suggests that each change of behaviour identified is dependent on the addition of a network. In these examples, adding a Network and the consequent change of behaviour descriptions, illustrate how entities co-evolve when change takes place.

4.5.2 Change propagation

Change propagation refers to moving from a before-the-change to an after-the-change situation (Etien and Salinesi, 2005). Change Propagation is illustrated in figure 14 as a part of *Evolution Requirements*. It shows the 5WH, the what, where (i.e., where macro, where micro), why and how of change descriptions. These include descriptions of driver, enabler, lever, and foundations for change. 5WH descriptions support reasoning about moving from before-the-change to after-the-change, through organisation-wide descriptions based in the present and/or over-time. The following figure 15 illustrates examples of 5WH descriptions abstracted from the case study. The first four designations (i.e., the what, where (macro), where (micro), why of change), provide information for problem analysis related to an existing situation when considering change propagation. They facilitate reasoning about relationships related to what change is, where it occurs and why. The how of change, the fifth designation, facilitates problem analysis of descriptions that affect change propagation (i.e., moving from the before- to the after-the-change situation).

Change Propagation (5 WH) – City of Tampere example descriptions

An improvement in the City of Tampere's *City Administration Service* provision to *External Services* is required in order to make information more readily available.

1. *What of change* – an internal computer network added to the City's information service provision for the City, local universities and the local telephone operator (i.e., External Services*)* (Anttiroika, 2004 - p.374).
2. *Where of change (macro)* – Change is located within the wider environment within which the City operates ''*…incorporating City, local universities and the local telephone operator…*'' (i.e., External Services*)* (Anttiroika, 2004 - p.374).
3. *Where of change (micro)* - change is located within the ''*… IT back office domain managed by the Communications Unit of City of Tampere Administration…*'' (Anttiroika, 2004 - p.371).
4. *Why of change* - driver(s) represent the force(s) from which change is initiated in the present and/or over time. One driver over time could be identified as the overall plan ''…adopted for the evolution of e-government services based on four stages of transition to e-government…'' (Anttiroika, 2004 - p.372).

Another driver from the wider environment in which the City existed was the ‘’…emergence of new and exciting experiments in the use of technology…’’ (Anttiroika, 2004 - p.375). One driver in the present could be moving towards e-government being seen as much as possible as a part of ‘’*…everyday work and development of administration.…*’’ (Anttiroika, 2004 - p.371).

5. *How of change* – enabler, lever and foundation statements inform change implementation in the present and/or over-time.
    - *Enablers* – The ‘’*…commitment to e-government since the early 1990's…*’’ with a focus on ‘’…e government implementation activities provided by the Information Technology Centre of the City of Tampere…’’ (Anttiroika, 2004 - p.371).
    - *Lever* – The focus on ‘’*…administrative machinery within line management to complete administrative, preparatory and development functions.…*’’ (Anttiroika, 2004 - p.371).
    - *Foundations* – Underpinned by the hard and soft infrastructure tools and techniques of the City of Tampere's ‘’*…actively built up information networks since the 1980's...*’’ and the consequent deployment of emerging technologies (Anttiroika, 2004 - p.374).

Figure 15 - Change propagation (5WH) - City of Tampere

Further background information supports the 5WH approach. This is provided by case study descriptions of the developing context in which the City of Tampere progressed toward e-government. The following questions were addressed in the early 1990's (Anttiroika, 2004 - p. 373):

- Through what kind of process was the internet introduced and adopted by the City of Tampere?
- How did city administration aim to guarantee citizens access to its electronic information and services?
- In what order did the city administration start to provide residents with different types of e-government services and tools of e-participation in particular?

General implementation difficulties included (Anttiroika, 2004 - p. 376):

- Work burdens and technical difficulties.
- Reprocessing of existing documents.

- Different '…appealing and stylish…' publishing required rather than traditional paper printouts.

Toward the late 1990's, lessons learned included the need for:

- A contextual and strategic approach to IT issues that included access to information, citizens computer literacy, authentication, public and private organisations ability to utilise technology when interacting with city government.
- The generation of a 'critical mass' that provided a sufficient level of e-enabled consumption and utilisation.
- Added value from e-services that promote their use.
- Content of services that was not perceived to be too thin.
- Support for potential increased workload when using new tools.
- Mitigating new e-enabled practices increasing the burden on administrative machinery (Anttiroika, 2004 - pp. 383-384).

4.5.2.1 Problem analysis

The 5WH provides a broader view of those aspects that can influence the transition from the before- to the after-the-change situation. Considering the City of Tampere's previous experience of change suggests an embracing approach to change (Appendix 2 Glossary B). For instance, the City's continuing experience of information networks having been built up actively since the 1980's, and the detailed context described for the 1990's, suggests an on-going experience of adapting to change. Evolution requirements could be facilitated if the post 1980's experience has developed adaptability in the workforce, with the staff having what Stacey would refer to as an open change approach (Stacey, 1990). Further (5WH) reasoning suggests different relationships and consequent alignments. *Where of change* (micro) and *where of change* (macro) represent the relationship between organisation providers of the service, and users of the service. In the *why of change*, linking drivers over time to drivers in the present, keeps a focus on the relationship between strategic direction and operational activity. Enabler, lever,

and foundations represent a relationship between City implementation activity (i.e., support for change), City administrative machinery (i.e., actions through which change is realised), and existing City IT/networks (hard and soft infrastructure that determines the capacity and capability to deploy change). Identifying these relationships provides a further reference for maintaining alignments and avoiding mismatches, during the process of technology change. One potential misfit refers to the Communications Unit. This has general administrative responsibility for e-government activities in the City. When managing e-government, the unit emphasises communications and content more than technology (Anttiroika, 2004 - p. 371).

On completing change impact and change propagation descriptions, a *change adequacy argument* relates before and after-the-change descriptions to argue in which way the change problem has been solved by the after-the-change description. The following simplified example provides one change adequacy argument. This is located at a high level of change problem and change problem context description.

> When the City of Tampere *need descriptions* for adding a computer network to their provision of administrative services for External Services, the *completion* of change impact and change propagation descriptions, *provides* information to the organisation that *bridges* the description gap between the before and after-the-change descriptions, therefore satisfying the need.

4.6 Conclusions

Chapter 4 has illustrated how the framework can be applied to the analysis of a change problem in an authentic organisational case study setting. Relevant change subjects have been identified and the chapter has shown how patterns can be discovered that provide a predictable response to a recurring change problem. The chapter illustrates how the framework supports a unified approach to representing problems from the past, the present and the future. It also

shows how the systematic application the framework provides, transforms organisation information into a problem-centred approach to changing technology.

Applying the framework to the City of Tampere case study has facilitated describing and analysing the context in which change takes place. The *change problem context* and its before, after-the-change and evolution requirement artefacts, represent the City of Tampere's change situation when adding a network. Observable behaviour and effect descriptions represented parts of *tasks, technology and people* affected by change. From this approach, *subjects for design* have been identified. For example, subjects related to change impact and change propagation. The framework's approach to grounding problem analysis this way has provided an understanding of the material observable effects the City of Tampere service should bring about when adding a Network. The following descriptions provide more details of the application of the framework to the City of Tampere's changing context.

The framework's first expression of problem was considered by all three artefacts. This referred to changing relationships between non-IT / IT activity, with a focus on what should or should not be automated. One potential source for automation was identifying the origin that triggers the need for service by External Services. The example (i.e., adding automatic updates posted on External Services home pages) illustrated the impact on design of problem centred analysis. There would be a mitigation of the need for some 'require service' requests to 'IT Operator' that related to updates. This would represent an additional automated activity changing the relationship between non-IT/IT activity, and signal additional alignment of task, technology and people in the City of Tampere information system business process.

The second expression of problem described and analysed before-the-change and after-the-change descriptions. This illustrates how a problem centred approach can separate problem space from solution space, and facilitate the identification of characteristics of change. City of Tampere relationships have been identified in their respective artefact. Interface phenomena descriptions describe relationships between variables, facilitating the traceability and tracking of those parts of task, technology and people that need to be aligned. For instance, the business process described in after-the-change, has an alignment of the *Task* (require service electronically - *External Services*), with the *Technology* response (forward electronic request -

Network), and *IT Operator* (forward electronic request to alert *IT Operator)*. This separation of task, people, and technology parts, when describing business process, facilitates additional reasoning about change problems that go beyond technology. In this example, reasoning further about *IT Operator* activity could suggest a need for training, and/or when reasoning about *Task*, the implementation of new procedures. Each of these examples becomes the subject of design when adding a network. Completing the adequacy argument maintained coherence between business process and task, technology and people descriptions. This ensured that domain properties and relationships in *External Services* (i.e., task, technology and people) bridged the gap between the service (*City Administration Service*) and the provider, *City of Tampere*.

Applying the framework's e*volution requirement artefact* to the City of Tampere's changing context represents the third expression of problem. The framework's unified approach enabled a comparison between the *City of Tampere* before-the-change and after-the-change descriptions. In this consideration of change over time, change impact was a focus. Applying the category of change descriptions (e.g., addition, change of behaviour, etc) illustrates the characterisation of those parts of the City of Tampere context affected by change and their relationships. The addition of a Network to the City of Tampere's provision of an automated service has changed relationships in and between domains. There have been changes of behaviour in domains *City Administration Service, City Departments (Non-IT), IT, IT Operator,* and *External Services*. Characterising difference this way stimulates further stakeholder/reasoning about problems in the evolution of the City of Tampere requirements. For instance, detailed discussions could explore further *change of behaviour* in domains in the City of Tampere context represented by *External Services* (i.e., city services, local universities, and telephone operations).

Applying *change propagation* to the City of Tampere context has illustrated how descriptions established relationships and potential alignments, between the *what, where, why* and *how* of change. These could support the City of Tampere's need ''…to mitigate increasing the burden on administrative activity of new technology practices…'' (Anttiroika, 2004 - p. 373). Alignments have been described that support moving from before-the-change to after-the-change. For instance, the *Why of change driver* promotes ''*…e-government as part of everyday*

work and development of administration…'' (Anttiroika, 2004 - p. 374). This suggests a synergy when implementing change with the *How of change ''…City of Tampere build up of information networks since the 1980's and consequent deployment of emerging technologies…''* (Anttiroika, 2004 - p. 374). Whilst this experience of change underpins the City of Tampere change programme, it also suggests potential for a continuous approach to requirements elicitation. A fluid approach to changing requirements, as opposed to a static single step attempt, may be relevant for the City of Tampere. As stated in a recent conference call for papers, the evolution of an information system is a continuous process rather than a single step, with evolution being an inherent property of a system (CAiSE, 2010 - p.1)**.** Applying the framework to the case study context suggests a potential embracing approach to change. There are a number of other outcomes discussed in the following paragraphs.

Three applications of the framework could lead to the use of reference models by the City. First, to provide a bespoke framework that adapts the framework's level of generality to meet current City of Tampere characteristics abstracted from this legacy example. Second, there is a potential re-use when a completed application of the approach replicates a change in another part of the City of Tampere. Also, reference model applications for the City, could facilitate evolution of requirement approaches that reflect the traditional one off step approach, or the more fluid approach of a continuous process.

There have been limitations on what the framework can illustrate. These include constraints arising from using a legacy case study, which could be mitigated by direct engagement with the organisation. For example, one could discuss with stakeholders the level of generality to be adopted, and engage with them to identify errors, inadequacies and complexity, caused from sourcing alternative domain descriptions requested by a client/customer. Data availability was also restricted by the choices made by the case study author, and aspects of business process and task, technology, and people made available by the City of Tampere. Other limitations include the author of the thesis identifying subjects to be considered that normally would be selected by the client/customer.

In summary, the chapter shows how, when using the framework, a case study organisation-wide description of change (i.e., the addition of an intranet) can be represented at a general

level, which is nevertheless sufficient to stimulate reasoning about a significant number of detail subjects in the City's changing context. Three different representations of problem are identified in the City's changing context. These are unified with structures, techniques, notation and terminology brought together from the literature by the framework. Also, the approach has exposed, separated, and synthesised, the following subjects when considering potential subjects for design:

- business process from organisation,
- Non-IT activity from IT activity
- Before and after-the-change and evolution requirement descriptions
- problem space from solution space,
- tasks, technology and people,
- alignments and mismatch.

Overall, the chapter illustrates how the framework's utility and relevance can support transforming an Organisation's change information, into a unified problem-centred approach to reasoning about change: for showing how complexity associated with technology change can be represented systematically, how problems can be identified, and how reasoning about change can be realised. Using the framework's natural language and diagrammatic expression of structure, techniques, notation and terminology, has facilitated extracting information from the natural language and diagrammatic approach used by the City of Tampere case study author. The example has demonstrated how applying the approach could support the City in developing its own structures, techniques, notation and terminology facilitating a bespoke approach to developing its own language for change.

The chapter also shows how applying the approach to an organisation's legacy case study can provide experience of the process of change. In a real-world situation, stakeholder/users could be involved in a number of ways. The approach could be applied in an early stage, problem-centred, requirements elicitation workshop. As shown in this chapter, the approach can be applied to abstract information from existing documentation allowing stakeholder/users to speculate about missing descriptions. Also, using a legacy example illustrates how the early-

stage focus of the framework might be introduced into the requirements elicitation process. Each of these situations provides opportunities for understanding change, through stakeholder/users experiencing a process of change.

Chapter 5 extends the framework approach with its introduction of *change frame.*

Chapter 5. –Identifying organisation 'change problem context' patterns

5.1 Introduction

A pattern describes a problem which occurs again and again in the environment. The problem pattern can be associated with a solution to that problem, and the core problem and solution can be described in such a way, that the solution can be reused many times (Alexander *et al.*, 1977). This chapter addresses the third research aim enumerated in 3.1: '…to discover an approach for identifying patterns that provide a predictable response to a recurring change problem…' by introducing the change frame.

Patterns in the form of models and/or frameworks have been used to rationalise perceptions of difference, in representing initial basic foundations for understanding the nature of change (McWhinney, 1992). In software and organisation development, patterns have been used to standardise activities; for example, a pattern of critical variables may be introduced to help organisations manage their working practices (Tushman and Nadler, 1978). Patterns have also been used to identify and maintain important relationships. For instance, the framework for maintaining the relationships in requirements evolution between completeness, consistency, and correctness (Zowghi and Gervasi, 2004). Patterns can also support flexibility during change through the application of modular approach, the joining together of standardized units to form

larger compositions. For example, to facilitate replacement without disruption to a system as a whole (Pressman, 1992)**,** and/or to ease modification and encourage re-use (Pountain, 2001).

The chapter combines the conceptual framework approach with a pattern. We refer to this combination as the generic organisation change frame and its three variants. The change frame provides an approach for the recurring problem of representing an organisation change, according to the needs of different organisational/strategic locations in which it is realised. As with Alexander, it ensures that change is not dealt with in isolation when there are relationships between different situations. Adequacy arguments confirm that a change description is consistent in its representation of business process across different organisation locations. In relation to the conceptual framework, the change frame extends the scope for representing changing requirements by accommodating multiple contexts, and hence gives due attention to context when reasoning about problems and how change should be realised.

The change frame and its variants are presented, demonstrating how they capture detail while maintaining generality, and how they capture context more fully than in the conceptual framework alone (chapters 3 and 4). The chapter also incorporates Stage 4 case study data which is used to identify the change frame pattern. Stage 4 data was referred to in chapter 3 (3.4.2), and is detailed in Appendix 4 (4.2).

5.2 Real-world studies and organisation patterns

The case studies were considered with the aim of discovering patterns of recurring elements and relationships among them. Commonalities were looked for in 19 case studies in an iterative, inductive analysis. Those found were grouped into three categories:

1) *Subject*

Technology change in each case study related to a subject area. The subject areas which emerged were *data management*, *connectivity* and *alignment.*

2) *Macro-context*

The macro-context category represents reference in the case studies to links between an organisation's internal activities (intra-organisation) and the wider organisation environment, including other organisations that are part of the organisation' (inter-organisation) and even more broadly (extra-organisation), consistent with Porter (1985).

3) *Micro-location*

The micro-location category encompasses three locations representing the operational/strategic activity area in an organisation. We refer to these as strategic intent, manager transformation, and operation reality. Since the early 1990's, the focus on strategic thinking by writers on organisation development has formalised the interaction between strategic and operation activity (Senge *et al*., 1999). A strategic approach is realised at the operation location, following its transformation at the manager location. This micro-location category represents the more immediate environment of an organisation's activities.

Each category has three subsidiary descriptions. We found that subsidiary descriptions were not repeated sufficiently for each to be considered as a pattern in itself. An example in the first category (i.e., Subject) was the description 'connectivity'. Evidence of connectivity in the case studies was too inconsistent for structuring, and describing, a level of generality for a connectivity pattern. The three categories did recur sufficiently to be considered as patterns. For instance, in the micro-location category (strategic intent, manager transformation and operation reality locations), an organisation-wide change is realised differently in each location, reflecting the relationship between them. These related but separate interpretations of change, suggest a pattern for realising organisation change in these locations. A change frame based on this pattern would represent the recurring problem of realising organisation-wide change in different locations.

The consideration of the categories as candidate patterns referred to Jackson's work on problem frames (Jackson, 2001). The first question posed for each of the three categories was based on Jackson's approach to classifying problem - centred patterns:

1. Question 1: - To what extent does the category being considered meet Jackson's four distinctions of difference when differentiating between classes of problem frames (Jackson 2001)

Satisfying this question begins the process of identifying categories as change frames. It ensures that if more than one category is identified as a change frame, then there are generic distinctions between them. The four generic distinctions are:

- Their requirements are different.
- They have different domain characteristics.
- They have different involvements in the problem.
- Each has its own distinctive adequacy argument.

Each category met the Jackson criteria. For instance, the subject category's 'involvement in considering [the] change problem' (e.g. data management) is different from the macro-context category (e.g., extra-organisation) involvement in the change problem, or the micro-location category involvement in the change problem (e.g., operation reality).
As each category satisfied the first question, a second question was asked:

Question 2: Is there evidence in the case studies and the literature of descriptions in a category being related?

If change in one description were related to change in the other two descriptions (i.e., if the answer to Question 2 is 'yes') that would suggest a potential for a change pattern if in a category, change in one description was related to change in the other two descriptions. In this situation, the pattern requires a consistency across the category when considering change to any of its three descriptions.

The micro location category was the only category in which the required relationships between its three descriptions were found in both the case studies and the literature. The following descriptions illustrate outcomes from considering the other two categories.

The subject category included descriptions of alignment, connectivity and data management.

- Alignment: Examples include aligning existing technology, aligning existing technology with new technology, and aligning existing technology with existing business processes. Examples also include aligning existing technology with new business processes, and aligning new technology with new business process.
- Connectivity: Technology that provides communication, networks, extranets, etc.
- Data Management: These were described by adopting categories of computing use from the literature review: Data, Information, Knowledge and Wisdom (Skyrme, 2002). These encompass within their scope expressions of computing change that are not included in the previous two categories of connectivity and alignments.

The subject category was not adopted as a change frame for the following reasons. When considering case studies, the three descriptions (alignment, connectivity, data management) were represented unevenly. The level of detail for each appeared too context-specific for the three, as a category, to be a repeat pattern of a recurring situation. Interaction between the descriptions was unclear and inconsistent, and there was no reference to interaction identified in the literature. The disadvantages identified for this pattern, may have been a consequence of constraints in the case studies which future considerations may obviate. Some information from this pattern is preserved and described later when the adopted change frame is introduced.

The macro-context category identifies contexts in which change is located, described as intra-organisation, inter-organisation and extra-organisation. The reader is reminded of their descriptions consistent with (Porter, 1985):

- Intra-organisation refers to those activities managed by the organisation and incorporates employees, subsidiaries, etc.
- Inter-organisation refers to working with other companies connected with the organisation's regular activities and includes suppliers, subcontractors, etc.
- Extra-organisation refers to the wider environment that impacts on organisation activities and includes customers, consultants, competitors, etc.

These three descriptions provide a more detailed representation than the conceptual framework, of the wider environment in which organisations operate. Case study information did not suggest that this category should be represented by a class of change frame. The three descriptions provide a more detailed focus for representing change, and whilst they did appear in combination in the case studies, this was inconsistent and uneven. Change realised in the intra-organisation context can require its realisation in one of the other contexts (i.e., inter-organisation, extra-organisation) but not necessarily in both. There was no support in the literature for interactions between these three being necessary when change takes place.

As with the subject category, the constraints identified might be a limitation of the case study process, with a possibility that future work will provide additional support for a change frame classification. Aspects of this pattern have also been preserved and incorporated in the change frame introduced in the next section.

5.3 Generic organisation change frame and its three variants

The micro-location category contains three descriptions referred to as strategic intent, manager transformation, and operation reality. Combining this pattern of related organisation activity with an extension of the conceptual framework, results in a change frame classification referred to as the Generic Organisation Change Frame. There were a number of reasons for adopting this extension.

First, the literature review identifies a relationship between the strategic, manager and operation locations (Porter, 1985). The case study analysis also revealed that an organisation-wide technology change can be described differently, at the three strategic, manager, and operation locations. Change can be represented by different sets of description appropriate to the context in which the change is being managed. For instance, if the organisation is making an addition to its technology, the ‘what’, ‘where’, ‘why’, and ‘how’ of change description, could be different in each of the strategic, manager, and operation locations. Also, a description of

change at the strategic location can be transformed at the manager location, for it's realization at the operational location. Nine case studies had references to interactions in the strategic/operation area of activity, with nine referring to the operation area of activity.

Second, descriptions of these locations can be distinguished by using the terminology, deterministic and volitional (McWhinney, 1992). Volitional change is described as self-determinism (e.g., a manager at the transformation location deciding what a change should be), and deterministic change is described as a force independent of self (e.g., an organisation at a strategic intent location required to adopt new legislation).

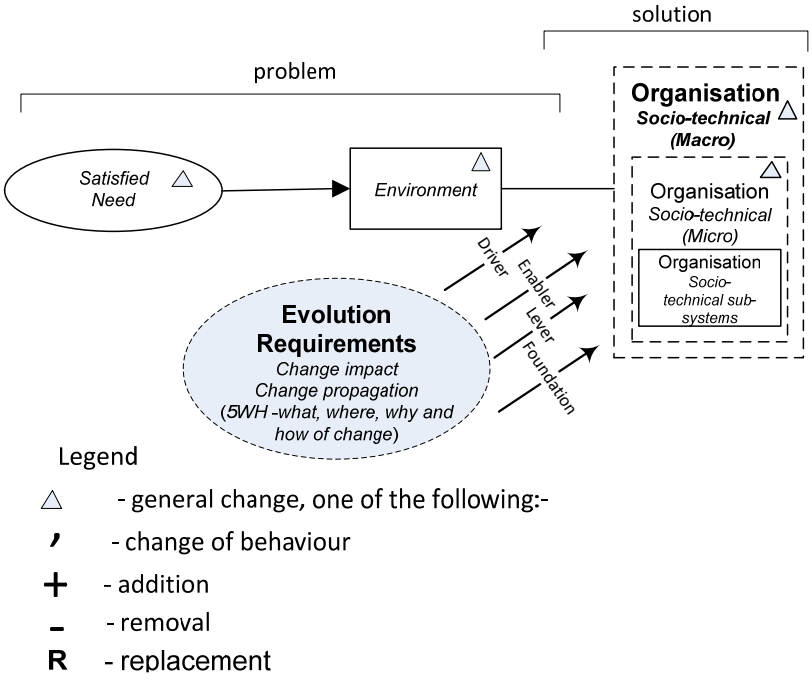
Third, these locations are related when, as a group, they are subject to organisation-wide technology change. Therefore, to represent different locations, we adopt the Jackson (2001) method of incorporating variants in order to structure a frame classification. A variant shares the central concern that characterises a basic frame (i.e., a technology change), but extends it to deal with some problem that doesn't fit the unmodified frame (i.e., different descriptions required for each location). We adopt the descriptions, strategic intent, manager transformation and operational reality as three variants of the change frame.

Fourth, whilst these three locations require different interpretations of an overall change, the context-specific nature of each constrains their application as a pattern in organisations. There could be organisation circumstances in which strategic, manager, and operation descriptions are not applicable. For example, small organisations may not yet divide activities this way; or when change is in the early stages of consideration, the consequences may still be unclear. To mitigate this constraint we introduce a fourth description, the generic organization, to which the three variants relate.

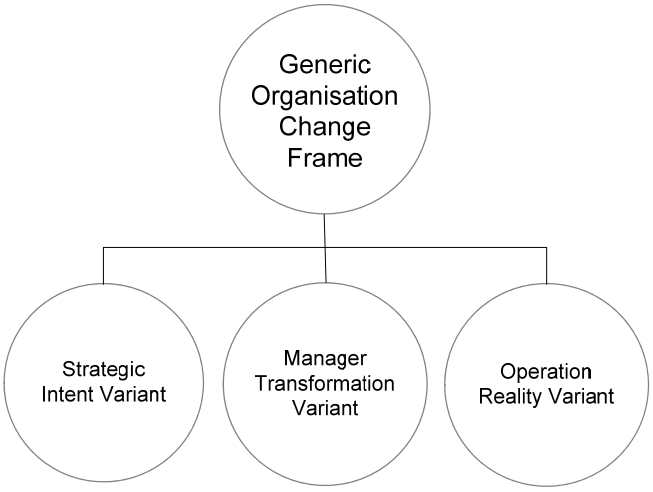
5.3.1 Change frame structure, notation and terminology

The generic organisation change frame extends structures, techniques, notation, and terminology of the conceptual framework. The framework provides a level of generality that

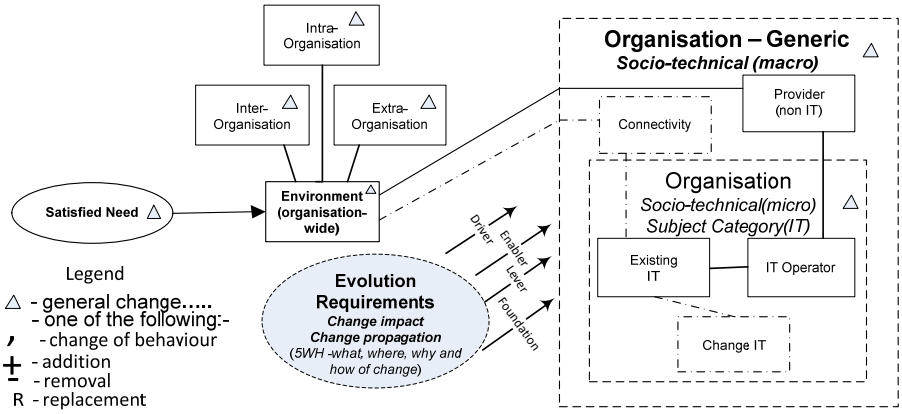
facilitates its application to a wide variety of organisations. The change frame is representative of a more specific change location, and incorporates more detailed structures and descriptions for stakeholder/user consideration. These differences reflect information considered from the literature review and 19 case studies. They are illustrated in figure 16.



16a – Conceptual framework notation



16b – Generic organisation change frame and variants



16c – Generic organisation change frame notation

Figure 16 - Generic organisation change frame

Figure 16 includes three diagrams:

16a The notation used in the conceptual framework, as introduced in Chapter 3, repeated here to remind and provide context;

16b, The organisation change frame and its three variants, and

16c The generic organisation change frame notation.

These diagrams are shown together to facilitate comparison of the underpinning framework's structure, techniques, notation, and terminology, to the extensions embodied in the generic organisation change frame. As the process for identifying descriptions from case studies has been illustrated using Tables 2 and 3 in chapter 3 (4.3), the repeat use of these Tables for this figure (referred to as Table 5 and 6) are detailed in Appendix 4.2

Figure 16c portrays three main areas of concern,

- *Organisation- Generic Socio-technical (macro)*. The two large dashed rectangles represent different but related organisation domains.
- *Environment (organisation-wide)* in the centre of the figure, and
- The focus for the change is represented by *Satisfied Need*. The organisation supports this in the *Environment (organisation-wide)* in which it operates (at the left of the figure).

The change frame extends the conceptual framework as follows:
Two domains, referred to as Provider (non-IT) and Connectivity, have been added to *Organisation - Generic, Socio technical (macro),* The *Provider (non-IT)* domain represents the non-IT service in the organisation. The *Connectivity* domain provides an IT connection between *Organisation-Generic Socio-technical (macro)* and *Environment (organisation-wide).* An example of this would be a network connection. The *Connectivity* domain is represented by a dot and dashed line in recognition that its existence in a before-the change situation has to be confirmed. These two additions reflect identification in all 19 case studies of technology used in communications, and descriptions of non-IT activity when providing a service.

The description *Subject Category (IT)* has been added to the *Organisation Socio-technical (micro)* description. Each of the 19 case studies identified the subject of its technology change. Three domains identified as *Existing IT, IT Operator,* and *Change IT* have also been added to *Organisation Socio-technical (micro).* In the 19 case studies, these three domains provided a general reference for scoping the more detailed micro context in which change takes place. *Existing IT* represents the IT that exists in a before-the-change situation within *Subject Category (IT). IT Operator* represents staff interfacing with IT who contributes to providing service. *Change IT* represents the technology change that takes place. *Change IT* is represented by a dot and dashed line; this signifies its omission when the frame is being used to represent a before-the-change situation, and its inclusion for the after-the-change situation.

Intra-, Inter- and Extra-Organisation descriptions are added to the *Environment* domain. In the conceptual framework, *Environment* represented both the macro environment (i.e., those parts having a deterministic influence on organisation, e.g., political developments) and the micro environment (i.e., those parts of environment the organisation can influence in a deterministic way, e.g., customers). The three descriptions now added to the frame (i.e., intra, inter, and extra-organisation) facilitate the identification of more detailed domain knowledge of the micro environment. As discussed earlier in 5.2, these three descriptions were represented in all case studies, individually, or in some form of combination.

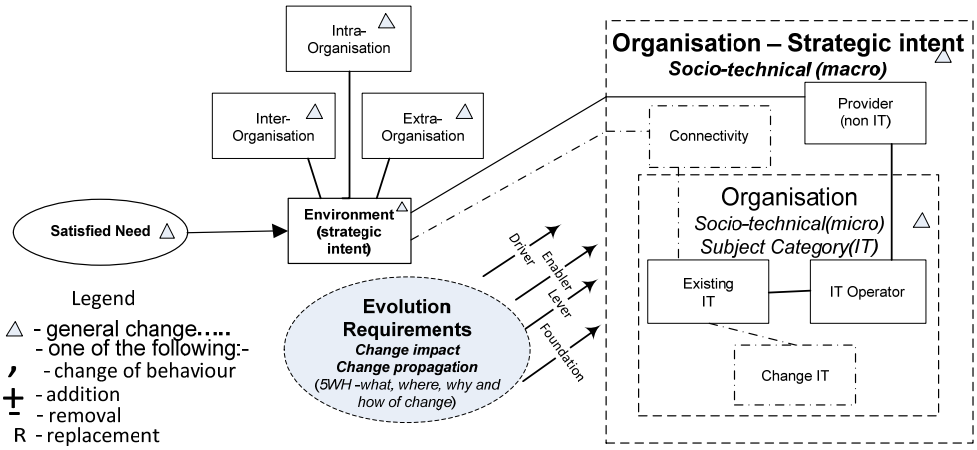
In summary, the generic organisation change frame (GOCF) provides a pattern which can guide reasoning about a recurring problem of technological change, in the wider, overall context

of an organisation. As presented in figure 16c it provides a general, organisation-wide class of recurring change problem. For instance, it could provide an organisation-wide representation of change in cases in which descriptions based on Cole's notion of decision making, and the critical variables of Nadler, were difficult to identify (e.g., when working with a less systematic management approach in a small and medium enterprise).

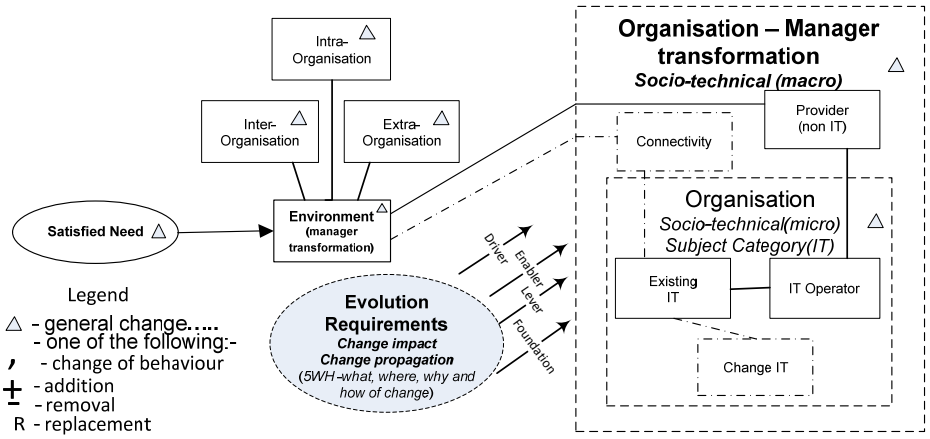
5.3.2 Change frame variants

The structure and notation for frame and variants is similar, the differences being represented by terminology that distinguishes each variant location. As with the conceptual framework, when applying the change frame, the differentiation of each location (i.e., generic, strategic, manager, and operational representations) is defined by the stakeholder/users (i.e., including client /customer).

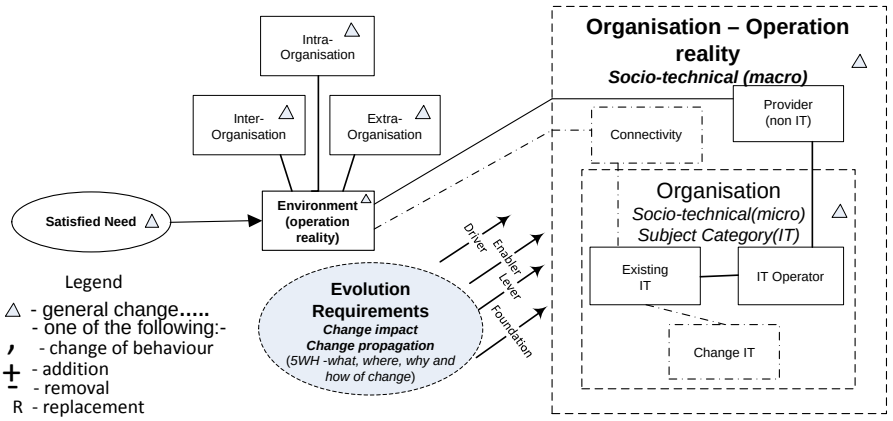
Distinguishing generic differences between variants is reinforced by abstracting further characteristics from the literature. Cole represents difference as a description of decision making in each location (Cole, 1988). The definition of decision making is different for the strategic, manager and operation activities. A location's description can also be represented by variables (Nadler, 1993), some of which are interactive and/or regarded as critical. This is shown in the conceptual framework, where change in one location requires change in another. The first part of 5.3 also referred to deterministic and volitional descriptions.



17a - Strategic Intent variant



17b - Manager Transformation variant



17c - Operation Reality variant

Figure 17 - Change frame variants

The Strategic Intent variant (SIV), illustrated in figure 17a, provides a systematic approach to representing change associated with a recurring problem at the strategic location in organisations. It is a particular class of recurring change problem in facilitating reasoning about change. This is a complex context, especially in terms of variables to be considered. These reflect the principal categories of decisions which are summarised as non-routine and non-repetitive (Cole 1998). Non-routine decisions reflect the occurrence of irregular variables in the environment (e.g., changes in legislation) having to be resolved with the variables in the organisation. Variables in the environment normally represent a deterministic change. The variables in the organisation are generally controlled by the organisation, and represent a volitional change. The strategic location is described by Cole as the place where basic, long-term (and hence non-repetitive) decisions are taken, which settle the organisation's relationship to its environment. Outcomes from these considerations are represented in the principal aims and objectives of the company. The SIV (17a) differs from the generic organisation change frame (16c) by the replacement of Environment (organisation-wide) by Environment (strategic

intent) and replacement of Organisation – Generic in the solution rectangle by Organisation – Strategic intent. These changes provide the subject focus for the application of SIV.

The Manager Transformation Variant (MTV), illustrated in figure 17b, provides a systematic approach to representing technological change associated with a recurring problem at the manager location in an organisation. It is a particular class of recurring change problem in facilitating reasoning about change. The MTV represents a location at which, according to Cole, managers are adaptive when responding to particular sets of prevailing conditions. The manager location is complex, as it represents the transformation of change described at the strategic location, to be implemented at the operation location. The principal categories of decisions at this location are summarised by Cole as short-term, routine, repetitive and frequent. Descriptive outcomes represent a change being described in terms of what is relevant at the manager level; and/or descriptions representing the transformation from the strategic intent location; and/or from external variables (each of which could be deterministic), to change communicated to the operation location. The MTV (17b) differs from the generic organisation change frame (16c) by the replacement of Organisation-Generic in the solution rectangle by Organisation – Manager transformation, and by the replacement of Environment (organisation-wide) in the rectangle by Environment (manager transformation). These changes provide the subject focus for the application of the MTV.

The *Operation Reality Variant (*ORV), illustrated in figure 17c, provides a systematic approach to representing technological change associated with a recurring problem at the operation location in organisations. It is a particular class of recurring change problem in facilitating reasoning about change. The ORV location receives decisions that the manager transformation location has decided are appropriate. These are in response to those decisions received from the strategic location. Descriptions of change at the operation location reflect the short-term, routine, repetitive and frequent decision making that Cole describes as typical of the context inherent in the manager location. Variables can be deterministic or volitional in character, and reflect the implementation of the principal aims and objectives of the company at the operation location,. The ORV (17c) differs from the generic organisation change frame (16c) by the replacement of *Organisation-Generic* in the solution rectangle, by *Organisation* –

Operation reality, and the replacement of Environment (organisation-wide) in the rectangle by Environment (o*peration reality)*. These changes provide the subject focus for the application of the ORV.

The change frame extends the conceptual framework's use of adequacy argument by applying a change adequacy argument when comparing before- and after-the-change and/or evolution requirement descriptions. The change adequacy argument ensures a business process consistency between before- and after-the-change descriptions. Where there is a combination using more than one set of before-the-change, after-the-change, and evolution requirement descriptions (e.g., all three variants together), the change frame introduces a synthesis adequacy argument. This ensures an organisation-wide business process consistency across those strategic/operational levels which are considered. It indicates that the satisfied need in each frame/variant situation has been met, whilst demonstrating the organisation change description has been interpreted consistently, in each location in which change is realised. To facilitate a comparison between them, the Generic Organisation Change Frame and Variants are included together in AP 4.3 – Chapter 5 – Diagrams.

5.3.3 Summary

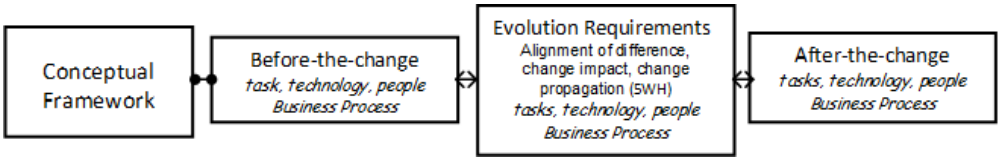
The frame and its three variants are each composed of structure, techniques, notation and terminology. The structure, notation and terminology are represented for example, in the change descriptions. Techniques are represented by the way an organization wide change description can be expressed differently in alternative organization locations (i.e., strategic, manager, operation). Each variant of the frame has three artefacts. As in the conceptual framework they are referred to as before-the-change, after-the-change, and evolution requirements. Each set of descriptions is distinguished by terminology that identifies a context-specific location. The frame can be applied in a number of ways. Examples include:

1. Applying the frame and variants together – an organisation-wide application where the strategic/operational area of activity is reasoned about, according to the context-specific location where change is realised.
2. Applying the generic frame or any of its variants individually – each representation (generic, strategic intent, manager transformation, operation reality) can be used for reasoning about, and describing, how change should be realised in a specific location for which representation is required.
3. Applying the generic frame to provide before-the-change descriptions followed by after-the-change descriptions from one/or all of the variants. This approach would be used when there is a general description of an existing situation. The organisation could then use this description to reason about context-specific after-the-change descriptions, at one or more strategic/operation locations.

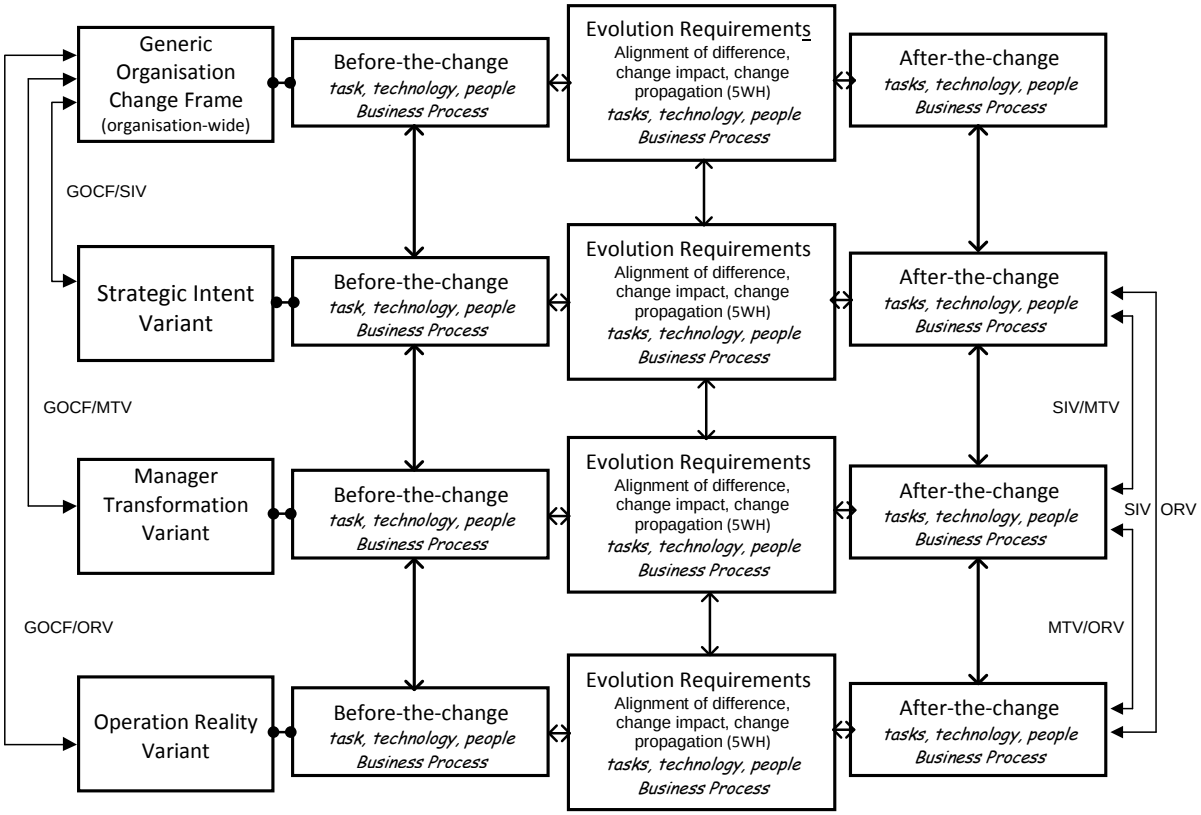
The synthesis adequacy argument extends the conceptual framework's use of change adequacy arguments. Applying the change frame and/or its variants increases the description of the change problem context (from that represented by the framework alone). The scope is defined by the combination of frame and variants used. For instance, when applying the generic frame, the change problem context would be scoped by its three artefacts of before-the-change, after-the-change and evolution requirements. Alternatively, when applying the frame and its three variants, the change problem context would be scoped by all four expressions of the change frame, and would include descriptions of each variant's three artefacts (i.e., before-the-change, after-the-change and evolution requirement). This extended scope prompts stakeholder/user group reasoning. There is an increased capacity for identifying task, technology and people relationships; a consequent increase in the number of alignment and mismatch interactions which are identified; and, an overall impact influenced by a potential multiplication of subjects identified for design.

5.4 Conclusions

Figure 18 illustrates the conceptual framework (18a) and the change frame with its variants (18b). The two figures are presented together in order to allow comparison and hence show the similarities between the two and the differences in scope.



18a - Conceptual framework



18b - Generic organisation change frame and variants

Legend

↕ Potential changing relationships between the generic organisation change frame and variants

Figure 18 – Scoping changing relationships in the conceptual framework and the change frame

In the figure, the arrow heads represent potential alignments and mismatches, of tasks, technology, and people in the business process. It can be seen that the potential for identifying relationships and consequent subjects for design, is much greater with the generic organisation change frame and variants (figure 18b), than with the conceptual framework (figure 18a).

The introduction of different contexts/perspectives through the use of the variants facilitates a closer consideration of the change problem. Each variant facilitates a more detailed reasoning of the environment where change takes place. Descriptions, relationships and their alignment extend those in the framework, and are embedded deeper in the context in which change takes place. Whilst the four perspectives together reveal a more comprehensive and potentially more complex changing context for problem analysis (than is captured by the conceptual framework alone), this is mitigated by the inherent relationships between each level in the pattern.

The change frame and variants improve the representation of those problems from the literature review which were incorporated into the conceptual framework. There is increased intelligence from early engagement of stakeholders, added complexity in scoping alignments and mismatches, and an enhanced and more complex context for reasoning about change over time (chapter 3.1.1). The multiple-context approach extends the framework, and there is an increased expression of flexibility. The locations for stakeholder engagement are many; there is an enhanced capacity for different characterisations of the terminology; and more than one level of generality can be considered concurrently, as can more than one set of the three expressions of the problem. Figure 18b illustrates how the multiple contexts are captured in a unified representation which can stimulate reasoning about relationships between contexts, and which prompts the identification of subjects for design.

The change frame variants represent three expressions of the problem, including twelve artefacts and their interfaces providing prompts for discussion and reasoning about the different expressions and their relationships. The GOCF can have a relationship with any of the three variants, and variants can have relationships with each other. These relationships are indicated by the arrowheads around the periphery of figure 18 This capacity to express a changing context has a consequent impact on the characterisation of the change problem, the identification of domain and interface knowledge, and relationships in business process. More

detailed information is abstracted through the separation of social and technical parts of an organisation, their interactions, and consequent reasoning about change going beyond technology. The change frame also extends the use of adequacy arguments in the framework, by introducing the synthesis adequacy argument. This confirms a business process across the pattern that maintains alignments and avoids mismatches.

Chapter 3 (3.1.1) identified the need for a common language for the different stakeholders involved in technology change (e.g., users, designers, developers, etc.). Along with the terminology for naming its variants, the change frame extends the framework's representation of a common language. The more in-depth interrogation of the organisation environment during the construction of the change frame produces a more detailed representation of natural language, diagram, structures, techniques, notation and terminology, than does the framework alone. As with the framework, these additions have been derived from both requirements engineering and organisation development.

The change frame, like the framework, can be used as a reference model for reasoning about organisation-wide change in strategic, manager and operation locations – and for facilitating comparisons across those locations. The impact of changing non-IT/IT activity on task, technology and people at one organisation location, can, using the change frame variants, be compared across different organisation locations. These task/technology/people alignments can be reasoned about, and confirmed across a wider context than in the framework alone. For instance, when comparing non-IT to IT activity carried out by tasks, technology and people in a vertical expression of the organisation (e.g., Head Office, Department, Team, etc.) or across an organisation (e.g., Head Office department, Subsidiary department, Supplier department, etc.).

Whilst there are differences between the change frame and the conceptual framework, they can be used in tandem. Their corresponding use of natural language, structures, techniques, notation and terminology, facilitates this type of application. Applying the framework first, with its higher level of generality, allows an organisation to clarify the change. This would then be refined and amplified by the application of the change frame's more detailed consideration of different contexts within the organisations: strategic, manager and operation locations.

The change frame, like the framework, was constrained by its derivation from the 19 case studies, the literature review, and the lack of forward citations for deriving a fuller set of case studies. Also, the change frame may not be applicable to every type of change problem. It is limited by being applied to specific areas of an organisation and, as with the framework, its concentration on physical phenomena and descriptions of observable behaviour and effects.

In extending the framework, it does provide coherence when change takes place in different but related organisation locations. There is a classification for a recurring change problem, an analysis that deconstructs a change context into fine-grained related contexts, a process that can lead to the classification of further change problems, and a wider scope for engaging stakeholders in understanding change, through experiencing a process of change.

In facilitating ease of modification and re-use, the approach aims to provide a continuing search for alternative recurring patterns of change. The principles used in finding recurring patterns (i.e., identifying and abstracting from commonalities), can be applied in different situations. These include an organisation context, an organisation sector, or across alternative organisation sectors. Experience gained using the change frame also facilitates the application of codified wisdom for reasoning about new change problems. Applying the frame supports our response to the thesis objective. It facilitates an understanding of change, through client/customer and stakeholder/users experiencing a process of change.

Chapter 6 provides an example application of the change frame to an authentic case study.

Chapter 6. - Applying a change-problem context pattern (linking with scenario/use case)

6.1 Introduction

In this chapter we use a typical scenario/use case University context to illustrate the application of the change frame and its relevance for considering change problems in an organisation setting. The University context selected has the problem of implementing an organisation-wide intranet. The example illustrates an analysis of the frame's combination of conceptual framework and pattern. Overall, whilst the chapter presents those aspects required to illustrate the fundamentals of the frame presented in chapter 5, it also provides through the use of additional techniques than in chapter 4, a more in depth and detailed experience of change for stakeholder/users (than in chapter 4).

6.2 A use case/scenario application

This chapter illustrates the framework's development process using the existing requirements practice of use/case scenario. Use cases are a well-established early-stage approach to requirements elicitation (Robertson and Robertson, 2006, - p. 73). They are adopted here for

three reasons. First, the use-case structure and terminology facilitate the presentation of the University real-world scenario to which the change frame is applied. Second, linking the change frame development process (i.e., from a theoretical to a real world expression) to the use-case approach suggests one route for incorporating the change frame into existing requirements engineering practice. Third, the story telling approach of the use-case scenario facilitates an understanding by stakeholder/users in moving towards identifying requirements. The scenarios, form the foundation for reasoning about requirements. (Robertson and Robertson, 2006 – p. 25).

In this University example, the representation of business process is adapted from the use case representation by Cockburn (1995). He referred to use cases as a collection of possible interactions/scenarios between a system under discussion and external actors related to a goal.

This representation of business process is referred to throughout the chapter as 'a sequence of scenarios leading to a goal' – it replaces the adequacy argument referred to in section 5.3.1. Reasoning about this representation of business process, as with adequacy arguments, aims at conforming to notions of consistency, completeness and correctness (Zowghi and Gervasi 2004). The task, technology and people subjects which are reasoned about emerge from interrogating a sequence of events leading to a goal, and are represented by reference to scenarios, their relationships and dependencies. Scenarios provide the focus for illustrating problem identification, changes in alignments and mismatch, and the unifying effect of combining structures, techniques, notation and terminology of the approach with an organisation pattern.

The change frame and its variants can be applied in a number of combinations. The combination selected in this chapter minimises repetition of the aspects of the conceptual framework illustrated in chapter 4. Instead, the focus is the pattern captured by the change frame, and the contribution it can make to identifying problems of relationships and their interactions when reasoning about those parts affected by change.

As with the conceptual framework, there are three steps to complete when implementing the frame. The first step captures before-the-change descriptions (i.e., general organisation-wide view), followed by the second step, which captures after-the-change (strategic intent) descriptions. Presenting these two steps demonstrates the application of problem analysis using

the change frame's more detailed structures, techniques, notation and terminology. The third step identifies evolution requirements. These descriptions identify problems of relationships across the pattern's three variants (i.e., strategic intent, manager transformation, operation reality), by comparing similarity and difference, change impact, and change propagation.

The remainder of the chapter is divided into five sections. First, the University domain is introduced based on the context of a medium/large University. This is followed by the three-step presentation of the change frame. Conclusions complete the chapter.

6.3 University domain description

The University's context for change is information management in the business process. Its aim is to pursue a knowledge management approach in order to gain competitive advantage over its marketplace rivals. The focus is the adoption of technology to develop its data management process. An Intranet is being added to provide a more competitive approach to the 'management of data'. The typical context of the University includes a satellite presence in all the regions of the UK and Europe, and there are a number of collaborative interdisciplinary partnerships that provide a global presence. Adding an Intranet will link University communities to its teaching and learning information.

Knowledge Management (KM) is a business process that emerged during the 1990's emphasis on the value of organisational knowledge. For example, Grant observed that the knowledge-based view of a firm is a spin-off from the resource-based view, because it highlights knowledge as the most strategically critical resource of the firm (Grant, 1996). Spender demonstrates how multiple actor organisations are influential in the processes of generation, storage, and application of knowledge (Spender, 1996). Since then, strategic approaches to KM have been developed in practice. For instance, (Kochicar and Suresh, 2004), in their report on Infosys Technologies Ltd. of India, noted that the application of KM encompasses organisation processes, responsibilities, and systems. These are directed toward the assimilation, dissemination, harvesting, and re-use of knowledge.

The University has implemented a number of organisation-wide knowledge management initiatives (e.g., workshops, seminars, change programs, etc.) and has deployed its computing technology mainly in desktop data management software packages. Examples include Microsoft Office, Adobe Acrobat, and Thomson Reuters Endnote. These have been supported by staff development workshops implemented over time, and reflect suggestions that technology can be used to leverage change in organisations (Harker *et al*.,1993). Non-computer activity includes access to administrative information, staff development, and employment information.

The author assumes the role of stakeholder/user in selecting those aspects of change considered. Where mentioned, client/customer and requirements analyst represent potential third-party contributions.

6.4 First Step: before-the-change descriptions (organisation-wide)

Figure 19 provides a reminder of the generic organisation change frame. Figure 20 provides the before-the-change stakeholder/user group descriptions of the University. To provide descriptions for figure 20 the stakeholder/use group concentrate on identifying elements relevant to the existing business process (i.e., not elements relevant to the addition of an intranet). These are expressed in a before-the change diagram. Interface descriptions are included (20a), and descriptions of the existing business process are expressed as a sequence of scenarios leading to the goal (20b). The goal in the before-the-change situation is an existing satisfied need (as in 19) expressed in figure 20 as Data Management (Competitive Advantage).

Figure 21a identifies the *University* as the Organisation - Generic (i.e., the provider of service). The Satisfied Need is *Data Management (Competitive Advantage),* and Environment (i.e., where the need for service resides) is *Intra-, Inter-, Extra-Organisation workstations.* As change has not yet taken place, the domain, Change IT, Evolution Requirements, and Legend of change elements, all in figure 19, are omitted from the before-the change diagram (20a). Also, as there is no internal computerised connection between *Intra-organisation (workstations)* and *University (Generic),* the Connectivity domain is omitted. Domain descriptions incorporate:

- *Intra-organisation workstations*: An abstraction of the University's UK, Europe and Global communities. This includes data management workstation facilities provided by *University (Generic).* There is no computerised connection to the University's Head Office.
- *University (Generic):* Incorporates *University Head Office (Non-IT).* This is an abstraction that represents all the University management departments and activities (i.e., including *non-IT*). It receives requests for information from its *Intra /Inter/Extra* domains.
- *Data Management (IT):* This is further decomposed into *Existing IT* (i.e., desktop and computerised systems), and *IT Operator*. IT Operator is an abstraction that represents the IT/non-IT interface between the University role of provider of service, and the intra-, inter- and extra-workstation need for service. It incorporates automated and operator response giving access to IT support, user support, confidential procedures, and staff development programmes in the use of Existing IT. University confidentiality procedures require all requests for information (i.e., and its acquisition), to be via IT Operator.

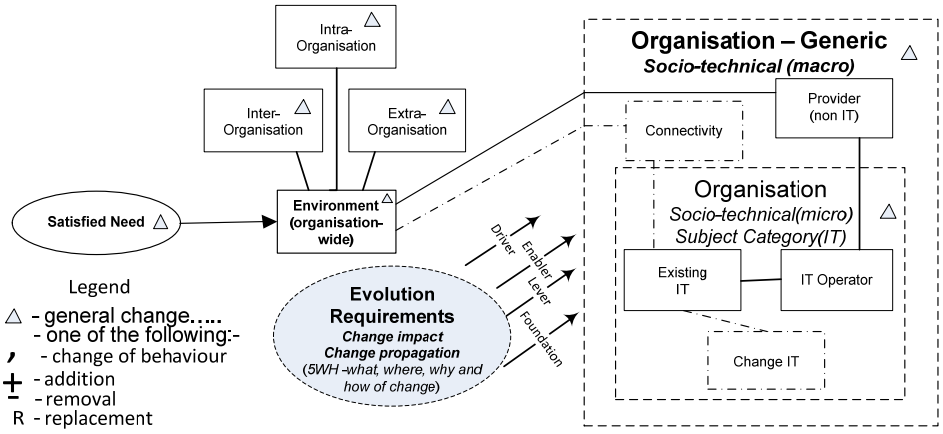
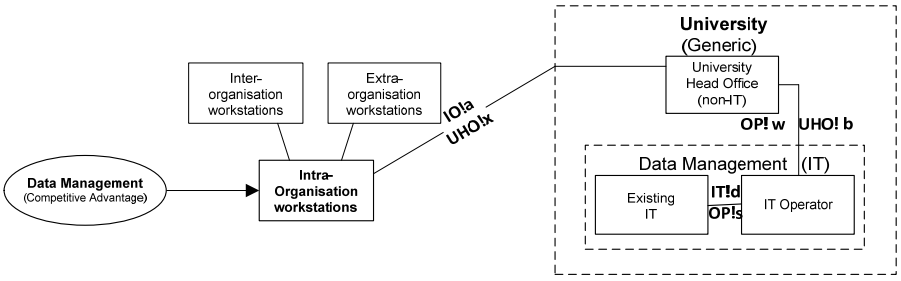


Figure 19 – The generic organisation change frame



a	*require service*	s	*access existing IT*
b	*forward request (or non-electronic information)*	w	*Request (or forward) non-electronic information. Provide electronic information*
d	*forward electronic request*	x	*provide service - satisfying need*

20a – Before-the-change description of the University

When intra/inter/extra workstations *require service* (a) for *data management information*, then the University Head Office (Non-IT) *forward request* (b) to IT Operator, who depending on the request *access* Existing IT (s) from which requested information *is retrieved* (d), or *non-electronic information requested* (w), and *receive non-electronic information* (b) or both, then *provide data management information* (w) to University Head Office (Non-IT), which *provide service* (x) to intra/inter/extra workstations, hence satisfying the need (x).

20b – Business process description – a sequence of scenarios leading to the University's goal of introducing an intranet

Figure 20 – Before-the-change (University - organisation-wide)
Stakeholder/user group descriptions of the University

The competitive advantage need which is currently satisfied by the University is that of providing data management support to its intra-/inter-/extra-workstation domains. This is illustrated in figure 20a. That is, when the intra-/inter-/extra-workstation domains require data

management support (‘a’ in the figure), this is provided by the University (‘x’ in the figure). Figure 20b presents the business process between the system under discussion and its external actors (as diagrammed in 20a) that relates to the goal of providing an intranet.

The ‘sequence of scenarios’ description (figure 20b) represents the stakeholder/user group's selected mismatch-free, existing business process. The description reflects group reasoning about existing situations, e.g.,University (provider of the service), Intra-Organisation workstation (user of the service), and Data Management (Competitive Advantage) (satisfied need). Reasoning is expressed with descriptions of task, technology, and people. For example, different user descriptions can be compared to identify similarities and differences in the use of task, technology and people. From this, alignments, mismatches, and dependencies can be identified, along with potential subjects for design. Alignments are confirmed when service provision (University Generic), is realised in the environment described (Intra-Organisation workstations), thus meeting the satisfied need (Data Management (Competitive Advantage).

The business process sequence of scenario expression is arrived at in the early stages of the reasoning process. When first described, it can be regarded as an initial ‘sequence of scenarios’, and used as a reference point for interrogating further the domain knowledge it represents. How the sequence is interrogated can be decided by input from third-parties, such as clients/customers and/or requirement/business analysts. For example, there may be the need to evaluate the effectiveness and/or efficiency of the existing business process, and/or, to what extent support was provided for delivering existing non-IT/IT relationships. A third party suggestion might be a retrospective approach considering what works well, not so well etc. The scenario descriptions provide a basis for reasoning about correctness through querying consistency and completeness. Overall, the ‘sequence of scenarios’ provide descriptions that facilitate further interrogation by the stakeholder/user group. This is illustrated in 6.4.1.

6.4.1 Problem analysis - before-the-change scenarios

The following nine domain interface descriptions are narrative 'sequence of scenario' descriptions derived from figures 20a and 20b. These are events for potential discussion by stakeholder/users querying the involvement of non-IT/IT activity.

1. Intra/Inter/Extra organisation workstations require data management information from University Head Office (Non-IT) - (a).
2. University Head Office (Non-IT) *forwards* request to IT Operator - (b).
3. IT Operator *accesses* Existing IT - (s).
4. IT Operator *retrieves* electronic information from Existing IT - (d).
5. IT Operator *requests* non-electronic information from University Head Office (Non-IT) - (w).
6. University Head Office (Non-IT) *forwards* non-electronic information (b).
7. IT Operator *forwards* electronic information to University Head Office (Non-IT) (w).
8. IT Operator *forwards* non-electronic information to University Head Office (Non-IT) (w).
9. University Head Office (Non-IT) *forwards* data management information to Intra-/Inter-/Extra-organisation workstations (x).

The following simplified example shows how a scenario and its context, in this case number 3 from the sequence above, can provide intelligence on problems related to alignment, dependency and mismatch, and can help users to identify subjects for design.

Scenario (step one): IT Operator accesses Existing IT - (s)

This scenario suggests *an instantaneous response to an IT Operator's* click on a computer key. More in-depth consideration of this activity (section 6.3) reveals more descriptions of the context in which it takes place. Support has previously been provided

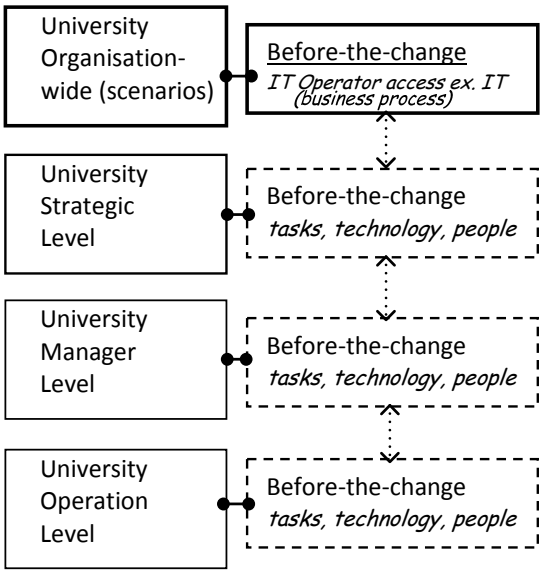
for *IT Operator access Existing IT*. Initiatives have been introduced that include on-going staff development workshops available in the use of *Existing IT*, and organisation-wide initiatives that incorporate change programs. The *staff workshop program* represents support for the continuing alignment of task, technology and people. *Change programs* **s**uggest the *Operator access Existing IT* context has a familiarisation with the process of change.

These initiatives imply an alignment and dependency association of staff development workshops and change programs, with the activity *IT Operator accesses Existing IT.* When changing technology, they provide potential *subjects of design* for the people aspect in the tasks, technology, and people representation of business process.

Review

Reasoning about the activity *IT Operator accesses Existing IT* (s) has shown how the descriptions in figure 20a, when expressed in a narrative scenario format, provide an alternative, context-enriching representation identifying alignments and dependencies. There are a number of references used to obtain descriptions for the wider scope of the context being considered. In this example, reference is made to organisation information provided in section 6.3, the University domain description. In a real–world situation alternative sources which might inform descriptions include individual users and/or stakeholder/user groups. Each source brings a unique context-aware perspective to the description of the wider context, and consequent access to potential alignments and dependencies. Applying this narrative scenario to all nine of the interface descriptions given in 6.4.1, suggests an increase in the number of relationships identified. Overall, looking at these narrative scenarios across the change fame pattern suggests the identification of multiple relationships. The scope for this is illustrated in figure 21.

6.4.2 Summary



Legend

Potential relationships across the pattern of tasks, technology and people

Figure 21 - Potential before-the-change IT Operator changing relationships across the pattern

The strategic, manager and operation variants are referred to as locations in the general body of the text. In the figures in this example they are labelled with the word *level* to register their traditional hierarchical application by organisations. The figure illustrates the four levels of the change frame pattern and the potential for identifying relationships between *IT Operator access Existing IT* University Organisation-wide (scenarios) and the other three levels. The arrows illustrate how relationships identified in each before-the-change level could be linked through alignment and mismatches *between* levels. The business process subject of the reasoning process (i.e., IT Operator accesses Existing IT) also affects the scope and extent of relationships identified. Using the change frame approach, stakeholder/user groups can interrogate the scenarios in order to identify the contribution made to the business process by task, technology,

and people activity. Interrogating individual scenarios facilitates 'drilling down' to identify more detailed domain intelligence than is evident in the 'Business process-sequence of scenarios leading to a goal' description (figure 20b). This corresponds to Jackson's view of *flavours* when considering variations in domain characteristics (Jackson 2001).

The frame's expression of interface descriptions as natural language scenarios facilitate stakeholders/user reasoning about them (section 6.4.1). Expressing them as a business process in natural language (figure 20b) enables stakeholder/user group reasoning to retain a coherence of alignments and dependencies. A consequence of using scenarios is the ease of access they provide to stakeholder/user contexts.

The scenario *IT Operator accesses Existing IT* is a subject in each of this chapter's problem analysis sections, and is used to illustrate how subjects of design in tasks, technology and people can be identified. Each step of the frame has an effect on IT Operator. The understanding of alignment and dependency relationships develops over the successive analysis steps; the example indicates how the frame's approach can be applied to individuals; and overall, the analysis shows the unifying effect of combining the frame's structures, techniques, notation and terminology, with an organisation pattern.

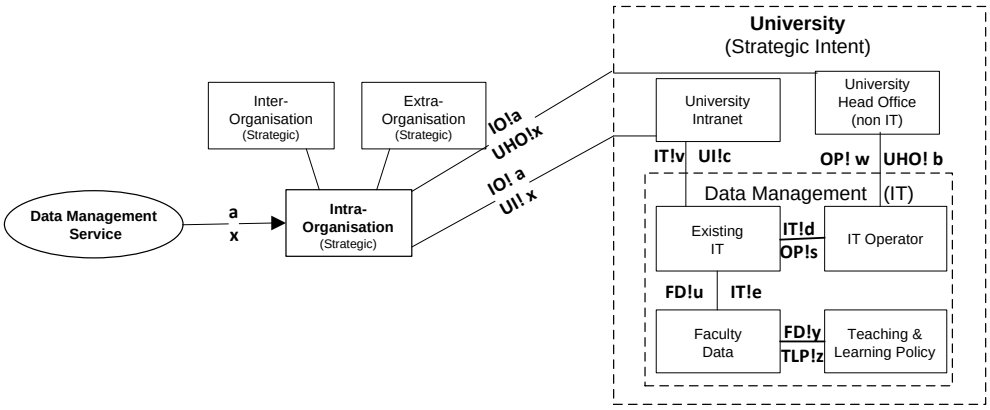
6.5 Second step: after-the-change (strategic intent)

After-the-change (strategic intent) descriptions, like before-the-change descriptions, are expressed using use-case scenarios. In this section, *italics* are employed to aid clarity for the reader. This is in addition to those uses described in chapter 1.2. In this chapter they highlight terminology that contributes to the development of a common vocabulary for stakeholders (i.e., users, developers, etc). A list of definitions is in Appendices1and 2.

At the strategic intent location, the University reacts competitively to external change from the generally *deterministic* pressure in the education marketplace. The University wants to improve its Data Management service to its Intra-/Inter-/Extra-Organisation communities. The change, the addition of a University-wide Intranet, is located within the IT department of the

University's UK Head Office. The IT department is *monistic* within a *closed change* situation, serving University-wide Intra-/Inter-/Extra-Organisation (Strategic) communities.

Obtaining after-the-change descriptions requires the stakeholder/user group to transform the before-the-change situation with descriptions representing the addition of the Intranet. After-the-change descriptions have been completed for each location in the change frame. Strategic intent descriptions are presented in this section, with manager transformation and operation reality descriptions presented in Appendix 4.4 – Chapter 6 - Diagrams, in order to minimise repetition. Figure 22 is an after-the-change version of fig 20. It includes after the change descriptions (22a) and the sequence of scenarios description of the business process (22b).



a	*require electronic and non electronic service*	u	*provide electronic information*
b	*forward non electronic request to IT*	v	*provide electronic information*
c	*electronic request to IT Operator*	w	*provide non- electronic information*
d	*forward electronic request to IT Operator*	y	*request electronic information*
s	*access Existing IT*	z	*provide electronic information*
e	*request electronic information from Faculty data*	x	*provide service*

22a - After-the-change descriptions (strategic) of the University

'…When Intra Organisation (Strategic) *requires service* (a) *electronically through University Intranet* (a) for Faculty data management information then it *forwards request* (c, d) *to IT operator* who depending on the request *access existing IT* (s) *and Faculty Data* (e) *for electronic information* and/or *request University Head Office (Non-IT) for Faculty non-electronic information* (w) who *provide* non-electronic information (b), then depending on the nature of the request, *IT Operator forward non electronic information* (w) to University Head Office (Non-IT) who *deliver service* (x) to Intra Organisation (Strategic) and/or provide *electronic information* (u, v, z) to the University Intranet from which Intra Organisation (Strategic) *retrieve* (x) electronic information, hence satisfying the need…'

22b – An excerpt from the business process described as a sequence of scenarios leading to the goal of introducing an intranet.

Figure 22 - After-the-change (University - strategic intent)
Stakeholder/user group descriptions of the University

After-the-change descriptions illustrate the changes made from adding an *Intranet.* *University Intranet* connects electronically to *Existing IT* and *Intra-Organisation (Strategic).* The domain *Faculty Data* is added, and connects electronically with *Existing IT*. *Faculty Data* provides electronic information, available for those requiring service from the strategic location. *Data Management Service* is an abstraction from Data management (competitive advantage) in before-the-change description. It represents the focus for strategic thinking about data management business process. The University still satisfies the same need as in the before-the change situation. It achieves competitive advantage through giving a *Data Management Service* to its *Intra/Inter/Extra-Organisation (Strategic)* domains. The service is now improved through the provision of *University Intranet* and *Faculty Data*. Now, *Intra-/Inter-/Extra-Organisation (Strategic)* has direct electronic access to data and policy in the University through *University Intranet*. From there, *Faculty Data and Teaching and Learning Policy* can be accessed

electronically. In figure 22b, the business process description reflects the changes to the business process (and consequent alignments and dependencies) entailed in adding *University Intranet*.

6.5.1 Problem analysis - after-the-change scenarios

The after-the-change scenarios can be interrogated to give detailed information on tasks, technology and people, in the context in which a scenario resides. The nine scenarios described below represent one sequence of scenarios for the changed business process.

1. Intra-/Inter-/Extra-Organisation (Strategic) *request* data management service electronically through University Intranet (a).
2. Intra-/Inter-/Extra-Organisation (Strategic) *request* non-electronic data management service from University Head Office (non-IT) (a).
3. University Head Office (non-IT) *forwards* the request to IT Operator (b)
4. University Intranet *forwards* the request to IT operator (c, d).
5. IT Operator *accesses* Existing IT and Faculty Data (s, e), and/or Teaching and Learning Policy (y) and retrieves electronic information (u, d) or (z).
6. IT operator *forwards* information (non-electronic request) to University Head Office (Non-IT) (w).
7. University Head Office (Non-IT) *delivers* non-electronic information to Intra-/Inter-/Extra-Organisation (Strategic) (x).
8. IT Operator *sends* electronic information to University Intranet (s, v).
9. Intra-/Inter-/Extra-Organisation (Strategic) *retrieve* electronic information from University Intranet (x).

Reasoning about after-the-change scenarios can be stimulated by outcomes from interrogations of before-the-change scenarios. Non IT resources could be connected to IT with

consequences from both new opportunities and possible changes to practice. For instance, section 6.4.1 discussed reasoning about the *IT Operator accesses Existing IT* scenario, in the before-the-change context. That simplified example is extended in the narrative below.

Scenario (step two): IT Operator accesses Existing IT - (s)

In the after-the-change business process, the IT operator *task* has been extended. In the new situation, the IT operator now has electronic access to the University Intranet and Faculty Data, as well as to Existing IT.

In the before-the-change description, change programs and staff development workshops over time have contributed to alignments being maintained in the business process. This suggests the need for an after-the-change approach that reflects these before-the-change support activities. For instance, completing a retrospective analysis of before-the-change staff development workshops and change programmes could identify lessons learned and what needs to improve. A refinement of before-the-change staff development workshop and change programs that incorporates a retrospective, along with the needs generated by new access to University Intranet and Faculty Data, would suggest a realignment of the business process task for the IT Operator. This changing business process suggests a dependency relationship between the application of both change programs and staff development workshops, with the alignment *over time*, of task, technology and people. It also identifies staff development workshops and change programs as subjects of design when adding an Intranet.

Review

Whilst after-the-change reasoning provides the opportunity to link retrospectives of before-the-change descriptions to the needs generated by new technology, the pattern facilitates

reasoning unique to specific organisation locations where change is realised. The reference to re-aligning the business process task of IT Operator is a general reference to the dependency between IT Operator and staff development workshops and change programs before-the-change. Using the frame's pattern of four levels to interrogate the University context more deeply about staff development needs, would provide change descriptions unique to the four locations represented. Change program and staff development workshop needs would be described, appropriate to the wider organisation and to the specific strategic, manager, and operation after-the-change situations.

6.5.2 Summary

The before-the-change (organisation-wide) and after-the-change (strategic) representations facilitate one change frame combination of descriptions, and consequent identification in the University context of relationships among task, technology, and people. Reasoning about after-the-change descriptions is founded on before-the-change descriptions. Completing retrospectives of the before-the-change situation provides an opportunity to ask questions about the relevance of non-IT/IT contributions to the business process, by existing task, technology, and people activity. In this example, using scenarios to interrogate the business process has provided an accessible and detailed approach to engaging with stakeholder/user groups. The systematic approach of the change frame has enabled relationships to be identified (e.g., *IT Operator accesses Existing IT*), between before-the-change (organisation-wide), and after-the-change (strategic intent) situations. For the stakeholder/user community, identifying alignments and dependencies of *IT Operator accesses Existing IT* across the pattern provides both intelligence and understanding of the changing situation. Relationships are then extended if the approach is applied to the manager transformation and operation reality variants. Considering other aspects of the University context of tasks, technology and people across the pattern, would

lead to the identification of multiple relationships. The potential for additional relationships is illustrated in figure 23.

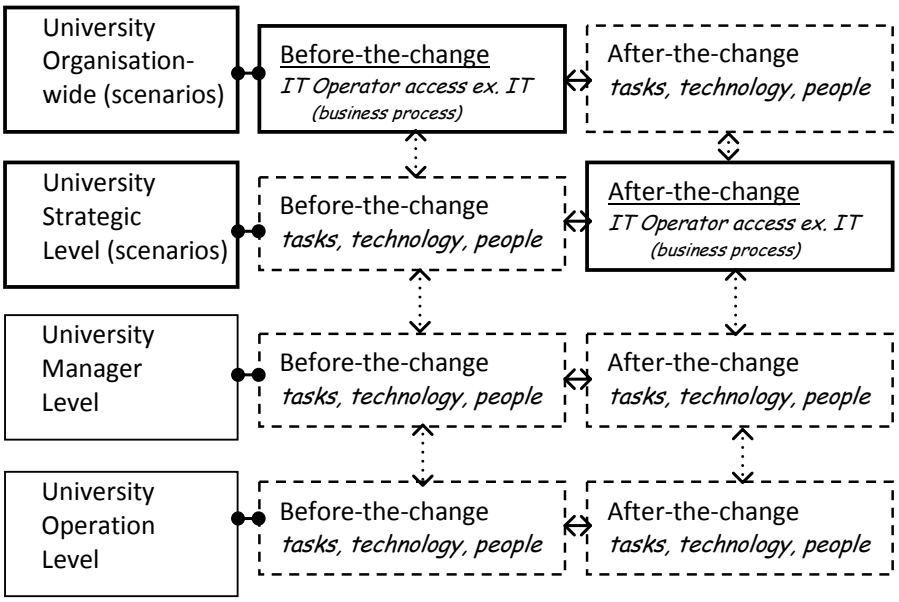


Figure 23 - Potential after-the-change IT Operator changing relationships across the pattern

The figure illustrates the relationship between University Organisation-wide (scenarios) before-the-change, and University Strategic Level (scenarios) after-the-change. The business process scenario is *IT Operator accesses Existing IT*. The dashed rectangles and arrowheads indicate the potential for additional relationships, should the rest of the pattern be applied. This potential is extended, if the consideration of the scenario *IT Operator access Existing IT* is expanded to include the other eight business process scenarios (section 6.4.1). The change frame has provided a unified and systematic approach to reasoning about multiple relationships in a complex changing context. Also, presenting before-and after-the-change descriptions has illustrated the change frame's more detailed descriptions of structures, techniques, notation and terminology than in the example in chapter 4.

6.6 Third step - evolution requirement relationships across the change frame

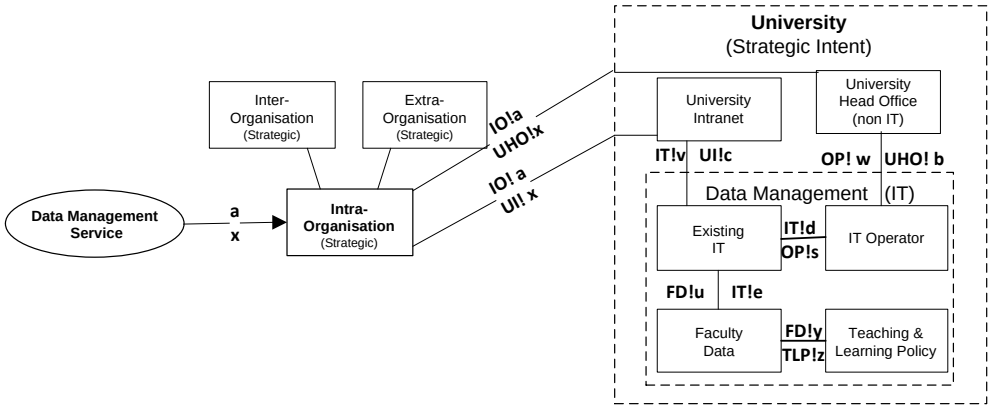
This section compares descriptions across the change frame's three variants (i.e., strategic, manager, and operation). First, after-the-change descriptions are compared, followed by change impact descriptions, and then by change propagation descriptions. These comparisons illustrate further how the change frame facilitates synthesis, when an organisation-wide change is interpreted according to the needs of different locations. Alignment of difference refers to difference and similarity between strategic, manager, and operation descriptions, when interpreting an organisation-wide change. Change impact, refers to potential alignments across the pattern of those parts affected by change. Change propagation, refers to alignments of organisation support across the pattern, when moving from a before to an after-the-change situation. In maintaining business process coherence during the reasoning process, the synthesis adequacy argument in figure 24 provides one expression of alignment across the pattern.

'…When University (before the change) *need* organisation wide alignment descriptions for adding an intranet, the location of which is scoped by the strategic/manager/operation variants, then *alignment of difference, change impact and change propagation* descriptions are *obtained* that transform before-the-change organisation-wide information, to an alignments maintained after-the-change organisation-wide description, which then *represents information* requested by University (before-the-change), hence *satisfying* the need…'

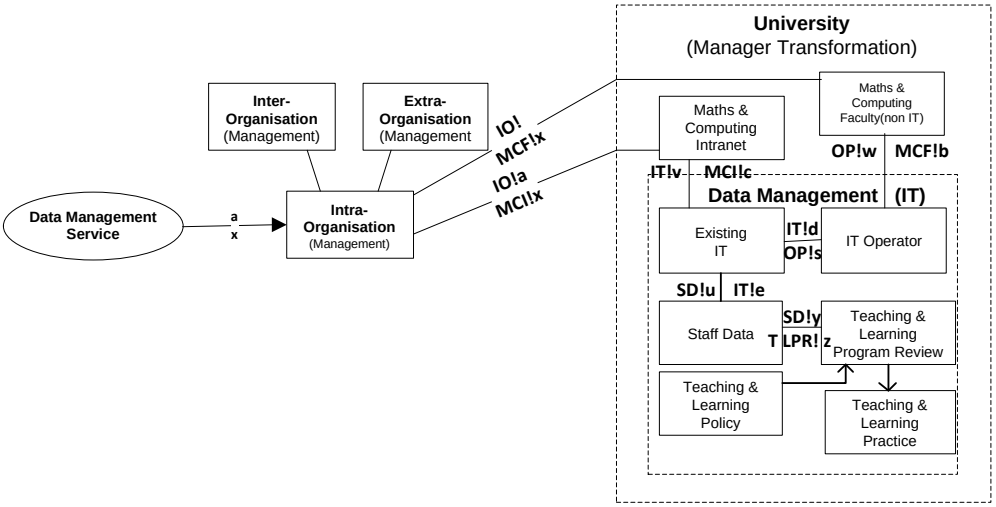
Figure 24 – Synthesis adequacy argument (i.e., alignments across the pattern) for Stakeholder / user group descriptions

6.6.1 Alignment of difference across the pattern

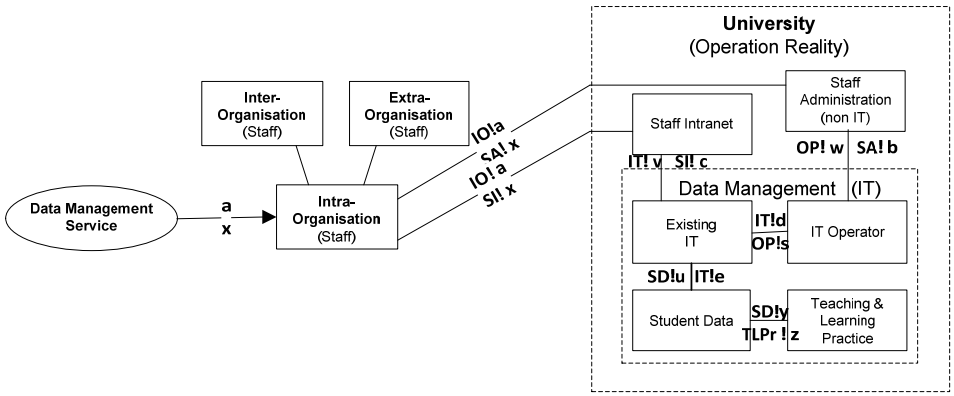
Alignment of difference refers to the pattern's different representations of the change description in each of strategic, manager and operation locations. The variant descriptions differ from each other, but collectively they represent an organisation-wide description of change. Distinctiveness between them is determined by different needs each location represents. Relationships are identified by designating *difference* and *similarity*. Understanding the relationships between variants helps in identifying interactions between the locations, and hence identifying how the differences can be aligned within the overall business process. The three locations of the pattern are illustrated in figure 25.



25a – Strategic intent – *after-the-change*



25b – Manager transformation – *after-the-change*



25c – Operation Reality – *after-the-change*

Figure 25 – Alignment of difference, after-the-change, between strategic, manager and operation

The figure represents strategic, manager and operation locations after-the-change. Each after-the-change diagram has three variables: *University* is the provider of the service, *Intra-organisation* presents the need for the service, and *Data Management Service* is the satisfied need the service provides. The use of a unified notation by the change frame and its variants facilitates a comparison across the pattern.

6.6.1.1 Problem analysis

Expressing alignment of difference as *difference* and *similarity* highlights both what distinguishes each variant description and the *relationships* between the variants. Domains, their interfaces, and/or their descriptions may be different. Alignment is achieved through the *similarities* between the variants. For example, the Intra-Organisation domain is represented in all three variants. *Difference* is indicated by the distinctions between Intra-Organisation user descriptions: in Operation Reality this is Intra-Organisation (Staff); in Manager Transformation it is Intra-Organisation (Management); and in Strategic intent it is Intra-organisation (Strategic).

The Teaching and Learning Program Review (T&LP Review) domain provides an illustration of transformation at the Manager level. In reflecting on the introduction of the intranet the University looks for opportunities to convert Non-IT resources and policies into IT approaches (e.g., Faculty, Staff and Student databases) The Teaching and Learning Policy (T&L Policy) domain reflects University Strategic Intent. It is interpreted at the Manager level through the T & LP Review domain into changes in the Teaching and Learning Practice (T & L Practice) domain to be implemented at the Operational level. This is shown in the differences in the three diagrams: (i.e., from T&L Policy (SIV) to T&L P Review (MTV) to T & L Practice ORV). When comparing variants at a more detailed level, alignment of difference is represented by different combinations in each variant's *University* and *Intra-Organisation* descriptions.

This difference in Intra-Organisation descriptions combines with difference in University descriptions. For example, the *Intranet* appears as *University Intranet* in Strategic Intent (25a), as *Maths & Computing Intranet* in Manager Transformation (25b), and as *Staff Intranet* in

Operation Reality (25c). The difference reflects the different contexts and communities in which each intranet is used, just as the difference in Intra-Organisation descriptions reflects the different intranet service needs. The similarity – the addition of an intranet in each location – indicates the basis of alignment across the locations. In a further example, there are domains which are expressed similarly across the pattern: *Existing IT* and *IT Operator* (and their interface). The similarity is highlighted, but there are nevertheless potential differences. For example, there is a potential need for a staff development program for the IT Operator at each location; however, each may require different content, such as a focus on strategic staff for staff development workshops for IT Operator in after-the-change (strategic). There are also different domains across the pattern, including *Faculty Data* in Strategic Intent; *Staff Data* in Manager Transformation, and *Student Data* in Operation Reality. The difference in expression highlights the different subjects of data being stored, yet they are similar in that each stores data.

Comparing these three variants illustrates how descriptions can be both aligned and different, when realising an organisation-wide change in specific locations. It also indicates that identifying similarity and difference can suggest requirement problems, necessitating further reasoning. For example, considering similarities and differences for data storage across the pattern, could include what aspects of procedures, laws, regulations, etc. should be accessible in each location. This illustrates the pattern's potential for identifying subjects of design, and the consequent extent and depth of the reasoning process.

Review

The Change Frame's strategic, manager, operation pattern has facilitated the transformation of the general description *adding an intranet,* to the more specific description required at each University location. The transformation around Teaching and Learning Policy illustrates relationships between the levels and gives an example of transformation at the Manager level between Strategic Intent and operational practice. The inclusion in figure 25b of domains Teaching and Learning Program Review, Teaching and Learning Policy, and Teaching and

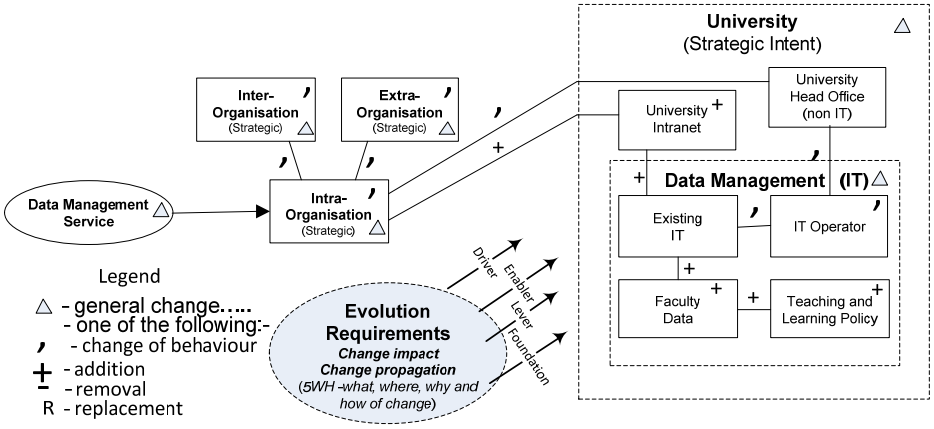
Learning Practice and the relationships between levels are reflected in the repeated domains at the Manager level of Teaching and Learning Policy and Teaching and Learning Practice.

This combination of levels within a uniform notation facilitates a systematic and unified approach to comparing levels. The examples illustrate in a number of ways, how reasoning about *similarity* and *difference* can inform alignment of tasks, technology and people. First, they distinguish potential alignments from potential mismatches across the pattern and provide the opportunity for further reasoning to mitigate mismatch and/or achieve alignments. Second, using the pattern to consider alignments provides a systematic approach to reasoning about, and consequently understanding, the over-arching context in which the locations co-exist. Third, reasoning across the pattern in the context of specific use-case scenarios, such as *IT Operator accesses Existing IT*, facilitates a detailed and systematic approach to initial identification of problems (i.e., developing an awareness of requirements in each context), not necessarily visible in an organisation-wide description of change. Fourth, completing an alignment of *similarity* and *difference* analysis across the pattern can be replicated across an organisation. It facilitates *reuse* in any recurring organisation situation the pattern represents. For instance, the example expressed here could be re-used (or modified for re-use) if a subsidiary of the University was going through a similar change.

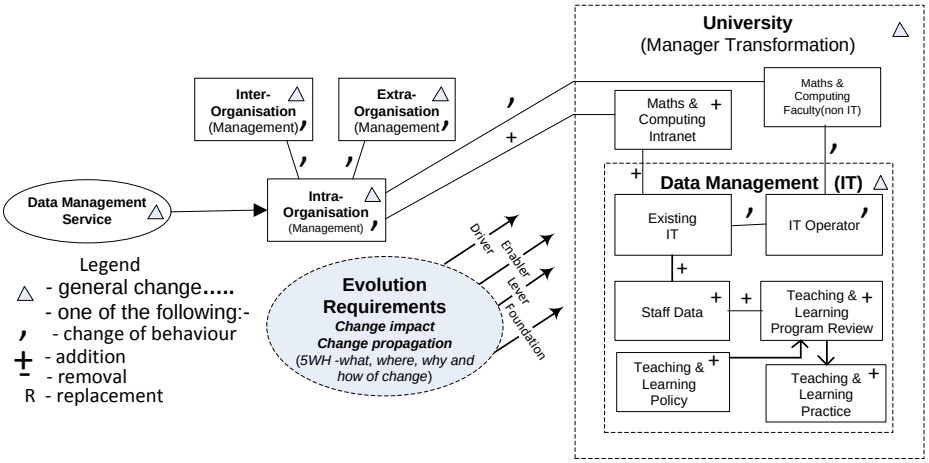
Reasoning about similarity and difference also provides stakeholder/users with an accessible introduction to considering relationships and alignments across the pattern. This reasoning is developed further when stakeholder/user groups reason about change impact across the pattern.

6.6.2 Change impact alignment across the pattern

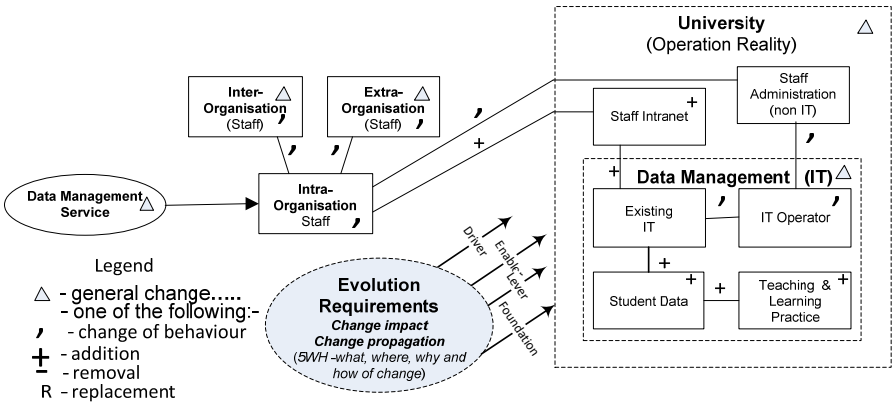
Change impact descriptions completed for the strategic, manager and organisation variants are illustrated in figure 26.These are arrived at by comparing each variant's before-the-change and-after-the-change descriptions.6.4 and 6.5 provide an example of before and after the change descriptions and there are after-the-change descriptions for each variant in Appendix 4.4.



26a - Change impact – strategic intent variant



26b - Change impact – manager transformation variant



26c - change impact – operation reality variant

Figure 26 – Change impact descriptions across the University change frame pattern

Each of the changes in the change impact descriptions is identified with a symbol for a category of change: *general change*, *change of behavior*, *addition*, *removal* and *replacement.* (A legend associated with each description maps symbols to categories.)

6.6.2.1 Problem analysis

In each of the strategic, manager, and operation diagrams in figure 26, the stakeholder/user group has identified a *general change*, *change of behavior* and *addition.* For instance, in each location across the pattern there is a *change of behavior* in the intra-, inter- and extra-organisation domains and two *change of behavior descriptions* at their interface. Five changes of behavior in each location, totaling fifteen across the pattern, give some early indication of potential *relationships* and their *alignment* across the pattern. For example, if *change of behavior* becomes the *subject of design* for a staff development program, there is potential for its alignment and coordination across the pattern.

Annotating changes explicitly, categorising changes and hence comparing change categorisations across the pattern, introduces an additional level of detail to the previous identification of similarity and difference. The identification of *general change* and *change of behavior* in the example provides a new focus for reasoning about *tasks*, *technology* and *people*, for example, when considering *change of behavior* across the pattern for *IT Operator accesses Existing IT*.

Scenario (step three): IT Operator accesses Existing IT - (s)

As described in section 6.4, the 'first step', IT Operator is an abstraction that incorporates both automated and operator response, giving access to IT support, user support, data confidentiality procedures, and staff development programs in the use of Existing IT. University confidentiality procedures require all requests for organisation information (i.e., and its acquisition) to be via the IT Operator.

IT Operator has a *change of behavior* designation in each of the strategic, manager, and operation diagrams. Whilst this represents a similarity, and by implication a potential alignment across the pattern, its description does not identify to which aspect of IT Operator it refers. Does the change of behavior refer to automated or operator response, access to IT support, user support and/or data confidentiality procedures? Also, does it refer to the same IT Operator subject in each location in the pattern?

The potential problems in this example suggest that the IT Operator context should be the subject of more in-depth interrogation by the stakeholder/user group. Identifying which aspects of IT Operator require a change of behavior, and what that involves, would clarify IT Operator task, technology and people parts affected by change. To illustrate how stakeholder/user group reasoning can progress we suggest one example based on *IT Operator access Existing IT (Strategic Intent).*

The Intra-Organisation (Strategic) electronic access to IT Operator (Strategic) could be the subject of an electronic filtering process that reduces real-time synchronous contact with IT Operator. For example, an automated response (e.g., text-based instructions and/or recorded messages), rather than real-time contact with IT Operator, could direct enquiries to appropriate locations. Applying this approach suggests an impact on both the user of the service (Intra-Organisation - Strategic) and the provider of the service (University - Strategic Intent). The change of behavior required in this situation could reflect the need to introduce new processes for Intra-Organisation (Strategic) and IT Operator (University-Strategic Intent). Hence, the change of behavior descriptions become the subject of design. Reasoning about new processes illustrates how the stakeholder/user group can progress when considering change impact descriptions.

Repeating similar automated responses in more than one location suggests potential alignment of Intra-Organisation and IT Operator activity across the pattern. In this situation the pattern facilitates a cross-pattern approach to implementing change. The IT Operator context, and the alignment of task, technology and people relationships, becomes the subject of design across the strategic, manager and operation pattern. There is consequent increase in the number of relationships identified.

Review

The Frame's change impact approach addresses aspects of *tasks*, *technology* and *people* at a more detailed level through reasoning about *change categorisation* descriptions. Categorisations can stimulate reasoning about relationships that interrogates change beyond the initial description categorisations represent. In the example, reasoning about IT Operator change of behavior facilitated the elicitation of context-aware descriptions from the stakeholder/user group, first by questioning which aspect of IT Operator reflected the change of behavior

categorisation, and second by reasoning about non-IT/IT relationships to find new uses for IT. Third, where automated response was repeated across the pattern, there was a potential cross-pattern alignment approach to implementing change.

The change impact approach can stimulate stakeholder/user group interrogations of context, within the scope provided by client/customer and/or requirements analyst. There are a number of parallels with alignment of difference. Similarities of change categorisations across the pattern suggest alignments within the University context across the pattern. Relationships identified can facilitate reuse and/or ease of modification in any recurring change impact situation the pattern represents. Also, reasoning about change impact across the pattern increases the potential for identifying multiple relationships, and consequently identifying alignments and dependencies in the university context. Thus, change impact analysis influences change propagation, moving from the before-the-change to an after-the-change situation.

6.6.3 Change propagation alignment across the pattern

Identifying the *what, where (macro), where (micro), why* and *how* of change (5WH) supports change propagation. The following example compares the *where of change (micro)* across the pattern. Figure 27 illustrates the first four 5WH descriptions which incorporate the *where of change (micro).* These descriptions incorporate *italicised* words which represent the on-going contribution to developing a common vocabulary for stakeholders/users. A list of definitions is in Appendix1and 2.

6.6.3.1 Problem analysis

The three variants in figure 27 (i.e., strategic, manager, operation) show that change associated with the introduction of an Internet has different locations in the different University contexts. In Change Propagation (5WH) strategic intent (27a), the *where of change (micro)* is

located in the *IT department* of the *University's Head Office*. In the equivalent manager transformation figure (27b), change is located in the *Faculty of Maths and Computing* (M&C). In operation reality (27c), change is located at a *staff member's (M&C) computing workstation*. The descriptions of each 'where of change' (micro) location also differ, as follows: in strategic, there is a *monistic, reactive contained change* situation; in manager, it is a *monistic embracing change* situation; and in operation, there is a *monistic, harnessing change* situation. Hence, *difference* is represented by reference to three different approaches to change: *containing change* in strategic, *embracing change* in manager, and *harnessing change* in operation. This suggests a *mismatch* across the pattern, as change is approached differently in each of these three locations. *Contained change* refers to minimising internal change, and represents a *reactive* approach to change; *embracing change*, whilst essentially *reactive*, promotes the notion of *adaptability* with a workforce that expects change; *harnessing change* refers to continuous change, where change is promoted as a source of potential benefit. A change management approach across the pattern will have to reflect these differences. *Similarities* across the pattern are represented by reference to *monistic change* experienced in each of the pattern's locations. Previous experience of monistic change in each location, which refers to moving things to being more alike, suggests some support to users when implementing change. For example, if as part of the change programme, users consider aligning the differences between locations across the pattern. The alignment across the pattern represented by *monistic* change in each location could provide a foundation for a *staff development* approach to aligning the *contained, embracing* and *harnessing change* differences identified. This example illustrates how stakeholder/user group reasoning about similarity and difference across the pattern, potentially mitigates an alignment problem in change propagation.

Change Propagation (5WH)

Strategic intent

1. What of change –To improve its Data management Service by the addition of a knowledge sharing University Intranet with electronic access to Faculty Data.
2. Where of change (macro) - The change is located within the generally *reactive external change* situation within which the University intra/inter/extra organisation (strategic) operate.
3. **Where of change (micro) -** The change is located within the IT department of the University's UK Head Office. *Monistic change* has been experienced within a reactive *contained change* situation serving University wide intra/ inter/ extra organisational communities.
4. Why of change (in the present and over time) Competitive external *deterministic* pressure from the education provider marketplace

27a Strategic Intent

(5WH descriptions for strategic intent)

Change Propagation (5WH)

Manager transformation

1. What of change –To improve its Data Management Service by the addition of a knowledge sharing Faculty Intranet with electronic access to Teaching and Learning and Student Data.
2. Where of change (macro) - The change is located within the generally *embracing change* situation of the intra/inter/extra organisation (Management) contexts managed by the Faculty of Maths and Computing (M&C). There is some suggestion of resistance to change in the IT Operator context.
3. **Where of change (micro) -** The change is located in the Faculty of M&C serving its intra/inter/extra-organisational contexts. It has experienced *monistic change* in an *embracing change* situation. The current change provides access to Faculty electronic information (e.g., Teaching and Learning, Teaching Staff).
4. Why of change – (in the present and over time).The University *deterministic* policy to use technology to make information more accessible.

27b Manager Transformation

(5WH descriptions for manager transformation)

Change Propagation (5WH)

Operation reality

1. What of change – To improve its Data Management Service by the addition of a Staff Intranet giving desktop electronic access to a Staff interactive Wiki and Student Data information.
2. Where of change (macro) - The change is located within the generally *embracing change* situation of the intra/inter/extra staff groupings of the Faculty.
3. **Where of change (micro)** – *Monistic change* has been experienced in the *harnessing change* situation of an individual staff members computing workstation in Maths and Computing. The current change provides electronic access to interactive Staff Wiki and Student Data.
4. Why of change (in the present/over time)-the *deterministic* policy of the Maths and Computing Faculty to meet University needs.

27c – Operation reality

(5WH descriptions for operation reality)

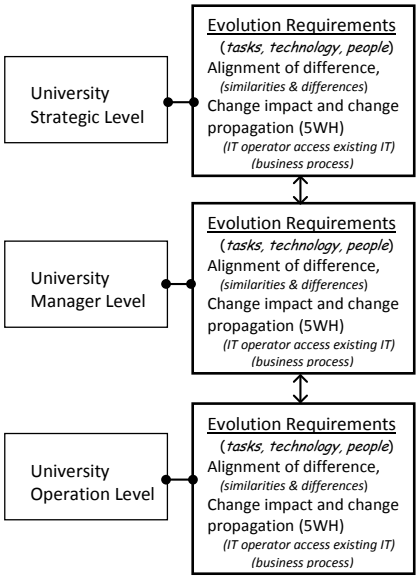
Figure 27 – Change propagation descriptions

Review

As with previous comparisons of levels, reasoning about change propagation (5WH) descriptions can mitigate complexity through identifying relationships across the pattern's expression of the University changing context. The first four designations (i.e., the what, where (macro), where (micro), why of change) provide information for problem analysis. These are related to an existing University situation when considering change. Each designation facilitates reasoning about relationships related to what change is, where it occurs and why. The example used referred to the where of change (micro) location in the University and showed how, when using the frame, reasoning can inform other aspects of 5WH. The example identified differences between University levels. It also identified the existing presence of monism, which could facilitate bringing these differences together. In this situation, monism would be the subject of design and become part of the program for the fifth designation of 5WH. This designation, the how of change, affects moving from before to the after the change situation.

While the example used suggests an application of the 5WH to the traditional single-step approach to change, a more complex application of 5WH would be required in an on-going more fluid approach to change. In a continuously changing context, the relationships between what change is, where it occurs and why (i.e., the what, where (macro), where (micro), why of change), and the how of change, would provide support for change in a more fluid environment. Identifying alignments and mismatches when moving from a before-to an after-the-change situation, would be a recurrent activity in a potentially more complex environment. The distinctiveness brought by the change frame pattern enables the identification of different descriptions for each of the three locations. The inherent relationships in the pattern facilitate the identification of alignments between locations. In the more fluid situation of continuous change, the pattern's representation of related but different descriptions of change would mitigate complexity by facilitating identifying University organisation-wide subjects for design. This potential is illustrated in figure 28.

6.6.4 Summary



Legend:

↕ Potential relations and alignments between levels

Figure 28 Change propagation relations and alignments across the change frame

Figure 28 illustrates the three levels in the pattern used to show evolution requirements. The arrowheads represent the potential for relationships between levels. The three subjects, alignment of difference, change impact, and change propagation (5WH), are descriptions at each level, enabling consideration of each subject at different levels, in comparison across levels, and across different changing locations in the University. Reasoning using the frame includes identifying alignments and mismatches of tasks, technology and people activity. From the diagram, it can be seen that different comparisons can be made across the pattern, with subsequent discovery of relationships between University levels. In the examples used, relationships were identified which were categorised as similarities and differences. This is illustrated by comparing *Operator accesses Existing IT* across all three locations. For instance, alignment of difference illustrated *different* descriptions of the University change context across the pattern. There was an IT Operator in a Strategic Intent context, a Manager Transformation context, and an Operation Reality context. There was a *similarity* across the pattern when comparing change impact descriptions. All indicated a change of behavior for IT Operator.

Similarity and difference descriptions and the consequent opportunity to reason about subjects for design, provide a supporting contribution to coherence when change takes place.

As with the before-and-after-the-change descriptions (i.e., step 1, step 2), the evolution requirement descriptions suggest potential for identifying multiple relationships in the University context; a consequent distinguishing of alignments and dependencies; and enabling a *reuse* and/or *ease of modification* in any recurring organisation change situation. The third step of the approach, identifying evolution relationships, can mitigate complexity, facilitate understanding, and promote awareness of the changing context, when moving from a before to an after-the-change situation.

6.7 Conclusions

Chapter 6 illustrates the support provided by the change frame when reasoning about change problems in an organisation real-world setting. The University context considered is characterised by figure 29, which shows the magnified context represented by the change frame in comparison to the conceptual framework (Chapter 3, figure 5). It also shows where multiple relationships have been identified by applying the change frame and the potential for identifying additional relationships.

In figure 29, the rectangles of continuous lines highlight the combination of change frame and variants considered in the chapter. University Organisation-wide (scenarios) Before-the-change and, University Strategic Level (scenarios) After-the-change are highlighted. Each incorporates *IT Operator accesses Existing IT* and Business process. Evolution requirements are also highlighted at the Strategic, Manager and Operation Levels. These incorporate alignment of difference, change impact, and change propagation. The broken line arrows illustrate potential further contexts for reasoning about alignments, mismatch, and consequent subjects for design.

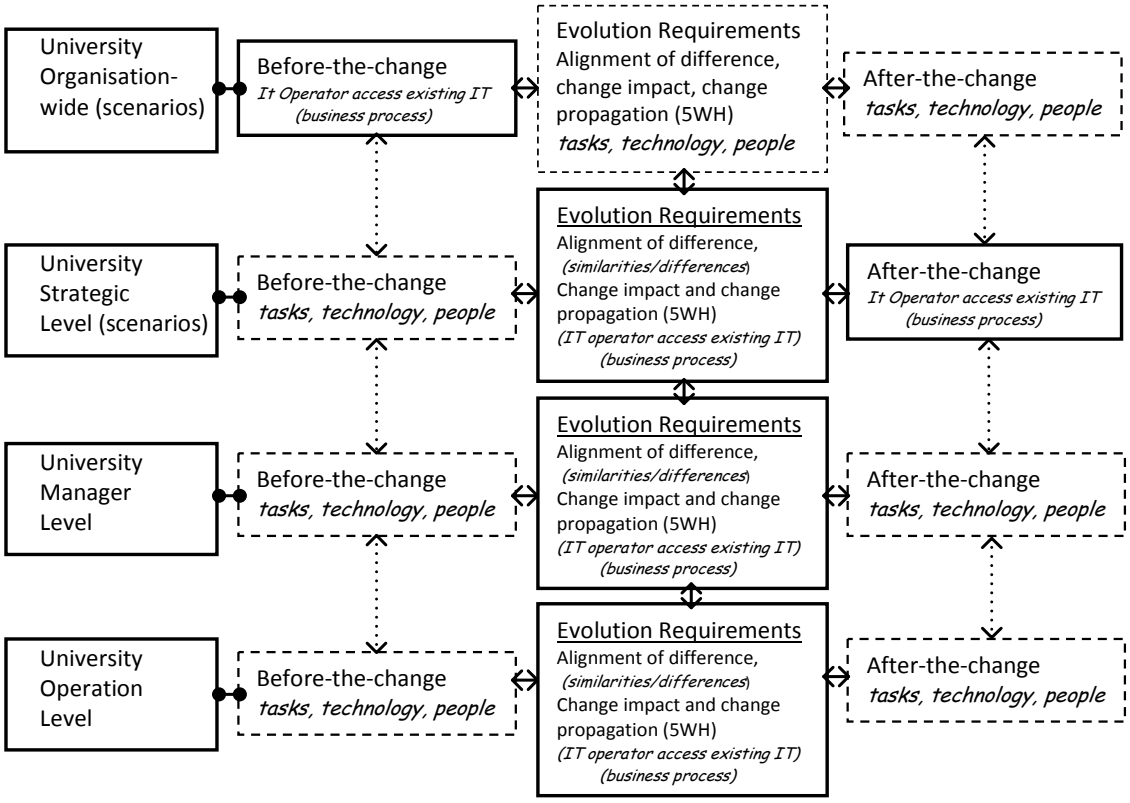


Figure 29 – Potential changing relationships across the change frame pattern

In summary, this chapter illustrates the appropriateness of the change frame and its utility in eliciting context-aware descriptions, supporting reasoning about change across an organisation, and identifying subjects for change. In reflecting the objective of the thesis it shows how combining the conceptual framework with an organisation-wide pattern extends the scope for engaging stakeholder/users in a process of change. In comparison to the conceptual framework, the change frame acts as a catalyst for representing a more complex context for change. The change frame's unified approach to expressing pattern gives it the potential to address

organisation-wide, multi-context complexity. The pattern facilitates the University organisation-wide descriptions of change being systematically broken down into relevant and more detailed descriptions. The context for changing technology is represented, problems are considered, and subjects for design are identified. Separate descriptions of change are realised at the strategic, manager and operation level with figures 25 and 26 indicating relations across the pattern between Teaching and Learning Program Review, Teaching and Learning Policy, and Teaching and Learning Practice. For instance in figure 25b, the transformation that can occur at the Manager level between strategic intent and operational reality is represented by arrow heads that link the domain Teaching and Learning Programme Review with Teaching and Learning Policy (strategic) and Teaching and Learning Practice (operational). The inherent relations in the pattern, and the application of adequacy arguments, ensure coherence during the reasoning process across the pattern as a whole. There are a number of other outcomes.

Using a use/case scenario context has limited what can be illustrated when implementing the change frame. The limitations identified reflect those in chapter 4. For example, direct engagement with an organisation's real world scenarios would have provided opportunities to connect with different stakeholder contexts. Examples include, organisation, group, and individuals in intra- inter, extra organisation contexts, including experience of their different applications of the approach. Subjects considered could include, choosing levels of generality, different expressions and uniqueness of business process activities, their accompanying scenarios and depth to which they are considered, detailed task, technology and people activity, the incidence of retrospectives, and the relevance and use of refutable descriptions, etc. A real world application would also have provided intelligence on choices made when using different variants in tandem, and the consequent identification of relations between them.

Overall, as with the conceptual framework, completed applications of the approach can facilitate re-use in recurring situations. Applying a scenario approach facilitates stakeholder engagement. It provides a link with existing requirements elicitation practice. A focus on *IT Operator accesses Existing IT*, gave an indication of the appropriateness the approach has for application by individuals. Also, the story-telling aspect of scenarios (i.e., natural language descriptions of experience) facilitates penetrating and abstracting stakeholder/user context-

aware knowledge. This assists 'drilling down' for more depth and detail, in identifying subjects for design. As Robertson and Robertson stated:

> *"…we have found scenarios to be effective, largely because of their ready acceptance by non-technical stakeholders..."* (Robertson and Robertson 2006 - p. 135).

Chapter 7. Discussion, future work, and conclusions

Chapter 7 reviews the aims of the research, evaluates the extent to which they have been met, and considers the relevance of the approach and the support it provides. Proposals are made for future work, and the achievements and conclusions are summarised.

7.1 Addressing the aim of the research

The thesis brings together concerns from the past, the present and the future. Recurring problems, complexity in the present, and a continuously changing context, suggest the need for a problem-centered approach to technology change in an organisation. This research has addressed: *"…how, in an organisation brown-field context, changing requirements can be represented, to facilitate identifying problems, and reasoning about how change should be realised."*

The approach presented is the response. Its two representations, the conceptual framework and the change frame, share structures, techniques, notation and terminology, drawn from both requirements engineering and organizational development. The examples in chapters 4 and 6 demonstrate the relevance of the representations and their utility in supporting the identification of problems and in supporting reasoning about how change should be realized. Hence their ability: *"...to facilitate an understanding of change, through client/customer and*

stakeholder/users experiencing a process of change...” in reflecting a need identified in the literature review.

This research has brought attention both to brown-field development, and the integration of technology change with business practice. The thesis presents a new approach (both a set of representations and a structured process of reasoning) that supports a problem-centered, business-oriented, user-accessible focus on context analysis when reasoning about changing technology in business processes. The new approach is presented and demonstrated in four major steps:

1. **The conceptual framework** (chapter 3), including its:

- Notation
- 3-Step process (before-the-change; after-the-change; evolution requirements – with reasoning about change impact and change propagation
- Adequacy argument

2. **Illustration of concept of the conceptual framework**: showing the framework in practice using the City of Tampere example (chapter 4).

3. **The change frame** (chapter 5), including its:

- Extension to the conceptual framework notation
- Use of variants to distinguish three key organisational ‘locations’
- Adequacy argument
- ‘Alignment of difference’ reasoning process – using analysis of similarity and difference to reveal issues and requirements

4. **Demonstration of concept of the change frame** (chapter 6), using narrative use-case scenarios as a means of elicitation (and to show one route to integration with existing requirements engineering practice) to describe the University example.

The conceptual framework and change frame, in combination with the three-step process, provide an overall framework for considering and describing technology change systematically in the context of an existing organisation. Different perspectives are described in turn (using similar notation). These include different perspectives in time, different levels of detail, and different organisational perspectives. The representations take into account tasks, people, and technology – and the relationships between them. These representations are compared, in order to identify differences that might reveal mismatches that need to be resolved, or to identify similarities that might indicate potential for re-use. The problem-centered analysis and its relationship to the overall context provides a means to systematically identify 'subjects for design' to support a technology change, with due attention to the organisation's business process, as illustrated in concept in chapters 4 and 6.

The process is user-oriented, designed to elicit stakeholder/users' knowledge of context, and to take its scope from their concerns. Organisation-wide stakeholder/user groups identify subjects to be considered, interrogate their own experience of them, and resolve disagreements. The conceptual framework and change frame encourage both general reasoning and an awareness of context. Social subjects as well as technical subjects are incorporated. Through reasoning about subjects of design, domain and interface relations, and alignment and mismatch, descriptions are synthesised using adequacy arguments. Completed arguments represent a coherent business process.

For example, the explicit descriptions required in the University example (chapter 6) are more detailed and capture more contextual information than those required in the City of Tampere example (chapter 4). The focus on *IT Operator* in chapters 4 and 6 indicates how the descriptions can represent an individual, as well as organisational change. *IT Operator* illustrates how a body of knowledge on change can accumulate throughout the application of the

approach. This shows how the approach can provide traceability of the changing business process environment from an individual (or role) perspective, as well as from a process perspective.

The approach can be applied to organisations in different ways: examining legacy examples to introduce the approach and/or inform an anticipated change, describing current systems during early consideration of technology change, considering the impact of alternative proposals, and so on. The approach can be applied in whole or in part. Even when information is incomplete, speculating about missing descriptions involves stakeholder/users in a process of change. Chapters 4 and 6 illustrate how identifying problems of potential change and reasoning about them systematically, promotes familiarity with the process of change.

Engagement with the variety of client/customer /stakeholder/users is facilitated in a number of ways. Levels of generality are described using a non-technical, non-formal approach, which combines diagram and natural language description. Reasoning concentrates on physical phenomena and descriptions of observable behavior and effects. Chapter 6 introduces use-case scenarios in an approach that reflects existing requirements engineering practice. Narrative scenarios assist stakeholder/users in accessing their own experience of a business process.

Where there is a need to standardise activity and/or represent a recurring situation, completed applications of the approach can be used as reference models. Re-using previously completed applications of the approach in recurring situations, leads to the embedding of a common language, and assists development towards an organisation-specific language for change. In these circumstances the approach provides the opportunity to use technology as a change agent. The pattern also facilitates organisations embedding a more formal approach to strategic and operational thinking. For instance, applying the frame where small and medium enterprises and/or parts of organisations want to embrace a more systematic approach to relating strategic activity to operation activity.

7.2 Future work

Whilst technology provides advantages for business, it also adds to the complexity when determining an approach to change. New uses for existing technology, new technology for existing uses, and new technology for new uses provide a context of continuously changing opportunities for organisations. Today, technology-driven change is ubiquitous, and the diversity of contexts means that multifaceted perspectives should be harnessed when considering any approach to change. The complexity identified in the present suggests a developing necessity to understand the context in which change takes place. The need to understand this context becomes compelling when one takes into account the additional impact of recurring subjects of change from the past and problems of change over time.

Fuller articulation of the process

The approach presented in this dissertation addresses change, but it is clearly only one step toward establishing a comprehensive treatment. Chapter 3 noted that the approach is not a panacea; although it can provide knowledge and understanding of the changing non-IT/IT requirements context, it does not provide a complete process for requirements elicitation nor produce demonstrably correct requirements. Its orientation to stakeholder/user engagement is not fully elaborated as a process of engagement (e.g., starting from ice-breaker introductions, elaboration of the facilitator's role, how 'experiencing a process of change' is conveyed across an organisation, etc.). The role of third parties, such as business analysts and requirements engineers, and the impact of the perspectives and techniques they might introduce, also need fuller consideration. All of these are subjects for further study.

Actual case studies: application to real organisations, with the involvement of stakeholders

Chapters 4 and 6, while demonstrating the concepts, provide only a partial illustration of their application. Although the work is grounded in the 19 real-world studies drawn from the literature, the research would be enhanced (and potentially refined and extended) by empirical applications 'in the wild' in organisations currently considering changing the technology they use. This type of application could inform our approach to structure, techniques, notation and terminology, for instance, by providing experience of organisations shaping the approach to meet their needs; client/customer/stakeholder groups interrogating domain information; and similarities between requirements engineering activities over time, that mirror business process activities over time.

Extension to other contexts

The change frame pattern has been applied to what might be termed the traditional vertical expression of strategic, manager, and operation activity. Over the last decade there have been flatter, more nimble organisational approaches to strategic/operation activities (Peters, 1998). There can be a more fluid representation of their inter-relationship. For instance, applying the change frame in the traditional approach assumes a sequence of strategic descriptions being transformed into operational descriptions. In the more fluid approach, initiatives can be identified in the operation context, which are then transformed into strategic descriptions. Developing the change frame principles to represent this more fluid approach is another subject for future work. Alternative contexts to consider include empirical applications to different organisation sectors, different organisations, and different organisational situations.

Assembling a body of 'candidates for re-use'

The principles of the change frame's over-arching pattern approach can be used to recognise other patterns. These could be inter-relationships identified between organisation partnerships,

subsidiaries, departments and/or teams. For instance, seeing similarities in the use of technology in an organisation's different situations, suggests a pattern for reasoning about efficiencies of alignment and mismatch. One topic for future work, particularly in applying an approach 'in the wild', is the collection of recurrent patterns into a body of 'candidates for re-use'.

Integrating this work with other techniques

Identifying similarities in requirements engineering practice and organisation development has suggested further potential for combining evolution synergies in our approach. For instance, comparing similarities between the Capability Maturity Model Integration and / or agile development (i.e., both from requirements engineering) with the organisation practice of knowledge management. The managing of knowledge has become a source of competitive advantage, and a consequent strategic focus in organisations. All three approaches engage with change over time, and incorporate the need to harness context-aware intelligence. The CMMI model is a process management approach (Glazer *et al*., 2008) and agile, with its application of 'process appropriate to project' (Robertson and Robertson 2006), has an embedded strategy to reduce the cost of change throughout a project (Highsmith and Cockburn, 2001).

The suggested synergy of organisation growth with requirements engineering gives substance to Nuseibeh and Easterbrook's statement that:

> *"...Managing changing requirements is not only a process of managing documentation, it is also a process of recognising change through continued requirements elicitation, re-evaluation of risk, and evaluation of systems in their operational environment..."*
> *(Nuseibeh and Easterbrook, 2000 – p. 3)*

On-going requirements elicitation would require an evolution requirement emphasis on tracking and traceability over time. Depending on the need, this could be expressed as an everyday activity. The sequence of steps followed in chapters 4 and 6 would be changed. In

these chapters, before and after-the-change artefacts were completed for their comparison to then provide evolution requirement descriptions. Changing this sequence would require evolution requirements to become the everyday expression of change. Before and after-the-change descriptions would represent steps in the process. For instance, steps for recording and monitoring the tracking and traceability of change over time. Harnessing automated tools and techniques could minimise potential complexities.

7.3 Conclusion

The aim of this research has been addressed by introducing an approach with two expressions. The conceptual framework provides a means of thinking about technology change in brown-field contexts in a way that gives due attention to the organization structure and its business process. We take a snapshot of the organisation before-the-change and after-the-change, and we use the elicitation of those snapshots, and their comparison, to reason about what the change requirements are, and to identify problems and conflicts that need to be addressed. Attention is paid throughout to the relationship between the organizational context and the business process context being considered.

The conceptual framework distils key information in a way that highlights elements of change so that stakeholders can engage in discussions about what's required and the relationship between proposed technology change and business process (or, can engage in reviewing past technology change in terms of the impact on business structure and process). It provides a 'lens' for considering change at a level of abstraction that is tractable – but also in a way that can handle more or less detail, depending on the user needs and concerns.

The change frame extends the conceptual framework to take into account key related organizational perspectives (strategy, manager, operations), in order, when changing technology, to support coherent decision-making from and between those perspectives. It is designed to capture recurring patterns of change, and hence to facilitate re-use of solutions both

within an organization and potentially between organisations. The demonstration of concept uses narrative use-case scenarios as a means of elicitation, and to show one route to integration with existing requirements engineering practice.

Both expressions of the approach support stakeholders starting and progressing their journey between their informal changing world, and the formal changing world of software behaviour. Both expressions support stakeholders in reasoning about software requirements in the context of changing business needs. However, we have some way to go to meet our long term aim, of automated tools that harness in organisations, continuous changing requirements.

Appendix 1 glossary A (requirements terminology)

artefacts

Representations of the change problem created when applying the conceptual framework or change frame. The specific artefacts are described as before-the-change, after-the-change and evolution requirement descriptions.

business process

Context of business activity identified by client/customer-stakeholder/users.

catalyst

Someone or something that encourages progress or change.

change impact analysis

Aims at evaluating how evolution requirements can affect the internal consistency of the evolving system and its compliance with other entities, and identify modifications that are estimated as necessary to preserve consistency.

change propagation

Moving things from before- to after-the-change; carrying evolution requirements into after-the-change.

codification

Structures, techniques, notation and terminology.

co-evolution

Species that influence each others evolution – analyse the reciprocal evolution of systems or software and other entities like organisations, business process etc., to identify those parts

affected by change - analysing the rationale for making systems evolve in coordination with other entities.

congruence

A consistency of variables in a specific organisation context.

context

General description for scoping a situation/circumstance.

context specific

Descriptions representing a particular context

control

Controlling causal phenomena – e.g., when applied to organisations, the power of directing or regulating.

control characteristics

Control characteristics of a domain refer to the control of its phenomena (e.g., whether it is dynamic or static).

domain descriptions

Concern for the domain interfaces (*its shared phenomena*) with other domains, and with its requirements reference.

domain flavours

In problem frames, each frame restricts both the content of your development descriptions and the argument structure they must fit into. But it does not restrict them very closely. There is still a lot of scope within the frame restrictions for variations in domain characteristics. The scope of each description is a set of phenomena of the domain; for each description you must consider the domains characteristics as they appear filtered through the lens of that scope. So when we talk about domain flavours, we are always talking about the flavours seen from the point of view of a particular description with a particular scope. In short, you will probably need to make several descriptions of each domain in your development.

environment

Represents the context in which an organisation operates.

evolution of requirement

Composed of evolution requirements and requirements evolution (Etien and Salinesi, 2005).

frame concern

Each problem frame has a frame concern. It identifies the descriptions you must make and how you must fit them together in a correctness (adequacy) argument. The argument must convince yourself and your customer that your proposed machine will ensure that the requirement is satisfied in the problem domain (Jackson, 2001- p38).

interrogate

Examine with questions.

level of generality

The explicit descriptions in the approach (i.e., determined by client/customer)

requiring subjective responses from stakeholder/users.

non-functional requirements

Defined as non-pertaining to the function (i.e., the observable behaviour) of the machine, or to the observable effects in the problem domain. Examples include, the date software is to be delivered, the description of what has to be tested, and the description, '… the software must be readily maintainable…' (Jackson, 2001- p38)

notation

An aspect of codification representing a system of figures, signs, symbols.

optative description

An optative description describes domain properties and behaviour that a machine in a problem must guarantee. By contrast an indicative description describes domain properties and behaviour that are known to hold irrespective of the behaviour of the machine (Jackson 2001, p367).

phenomenon

An element of what we can observe in the world. Phenomena may be individuals or relationships. Individuals are entities, events, or values. Relationships are roles, states, or truths.

problem frame

The definition of a problem class. A problem frame consists of a frame diagram, domain characteristics and the frame concern. It is a tool for classifying, analysing and structuring software development problems. A kind of pattern it defines an intuitively identifiable problem class in terms of its context and the characteristics of its domains, interfaces and requirement. Domain and interface characteristics are based on a classification of phenomena (Jackson, 2001 - pp. 76-85)

problem frame – variant frame

A basic frame is varied or elaborated in some way, often by the addition of another domain to the problem diagram. The variant shares the central concern that characterises the basic frame, but extends it to deal with some problems that don't fit the unmodified basic frame. Example variants are description, operator, connection and control. The first three add a domain the fourth modifies the control properties of the interfaces. An example of a description variant is supplied by the magnetic card reader a number of which are incorporated in a previously preset regime for 'stop and go' traffic lights. To change the regime only the card need be changed (Jackson, 2001 – pp. 207-8).

program

Language…set of instructions….

reference

A connection between a requirements and a domain or between a description domain and another domain. The connection consists of references to phenomenon of the domain (Jackson, 2001 - p.20)

requirement

The effects in the problem domain that your customer wants the machine to guarantee.

requirement analysts

Third party contributors to the reasoning process.

requirement reference

A reference by the requirement to some phenomena of a domain. It is represented in a problem diagram by a dashed line between the requirement and the domain. If the line has an arrowhead (pointing to the domain) the requirements reference is a requirement constraint (Jackson, 2001 - p. 50).

socio-technical system

Represents the complex interrelationships of people and technology which includes hardware, software, data, physical surroundings, procedures, laws and regulations.

software development problems

About the world outside the computer – the real environment in which the system must have its effect – and demand consideration about the surrounding characteristics, relationship and context (Jackson, 2001- p38).

stake/holder/users

Those with a volitional influence on the business context.

system

Rules, set of laws, convention, policy.

variable

A fluid state, rather than a static state.

Appendix 2 – glossary B (organisation terminology)

business analysts

Third party contributors to the reasoning process.

business process

Context of business activity identified by client/customer-stakeholder/users.

change control

Change control in organisations refers to how organisations control the environment in which change takes place.

change

Represents the process of becoming different.

change context

Represents where the process of becoming different takes place.

change [containing]

A reactive but progressive approach which is a response to a deterministic requirement to change realised by, for instance, organisations minimising internal change

change [embracing]

Reflects a more adaptable approach when reacting to change than that of contained change.

change [harnessing]

A proactive approach to change instigated for instance, by an employee suggestion for change.

client/customer

Represents those with a *deterministic* influence on business process.

code

Cipher - signs, symbols; system, rules, convention.

control

Refers to the power of directing or regulating causal phenomena (Cole, 1988).

critical variables

Critical variables provide a focus for the coordination and control of change in a context specific location in an organisation.

determinism

Actions determined through forces independent from self.

environment

Context in which an organisation operates.

extra-organisation

Customers, consultants, competitors etc.

flexibility

Flexibility assumes an organisation environment where change can take place.

inter-organisation

Suppliers, subcontractors etc.

intra-organisation

Internal to the organisation, for example, employees, subsidiaries etc.

macro environment

Those parts having a deterministic influence on organisation (i.e., political, social economic and technology developments).

micro environment

Those parts of environment the organisation can influence in a deterministic way, (i.e., employees, suppliers, customers).

management

A process to ensure the organisation meets its present and future needs. Generally this expresses a relationship between the deterministic and volitional.

monistic

Change moves things to being more alike.

non-IT/IT

In a business process, the relationship of non-IT activity to activity contributed by IT.

pattern

Represents a synthesis of important relationships.

pluralistic

When change moves things towards difference

Stakeholder

A person, group, organisation or system that can effect or be affected by the actions of an organisation.

volitional

Self determinism.

Appendix 3 – List of case studies

The following 33 case studies have been sourced from the literature, e.g., (http://www.idea-group.com). The initial group of 33 studies have been reduced to 19, selected for their focus on representing and describing change in technology.

1. IT5718 Workflow-Supported Invoice Management: The Case of a System Implementation at a German Media Company. Karl R. Lang, City University of New York (CUNY), USA.This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.
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2. IT5504LLNtea – Discussion Paper – From Pilot to Practice – Streamlining Procurement and Engineering at Lawrence Livermore National Laboratory - Judith Gebauer, University of California Berkeley, USA; Frank Färber, Darmstadt University of Technology, Germany.

3. IT5506scotlandNetwork - Network Implementation Project in the State Sector in Scotland: The Influence of Social and Organizational Factors; Ann McCready and Andrew Doswell, Glasgow Caledonian University, Scotland.

4. IT5717ERPAmBuidPro - ERP Selection at AmBuildPro; Margaret Sklar, CertainTeed Corporation, USA; Matthew Breneman, Micro-Coax, USA; Ira Yermish, Saint Joseph's University, USA.This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.
5. IT5575growthEvolution - Evolving organisational growth through information technology-Ira Yermish, St Josephs University, USA.

6. T5685QualityEvolution – The Quipudata Case: Implementing a Quality Initiative in an IT Organisation; Martin Santana-Ormeno, Antonio Diaz-Andreda, Jaime Serina-Nishimura, Edie Morris-Abarca, ESAN, Peru. This chapter appears in the book, *Annals of Cases on Information Technology* Technology, Volume 5 edited by Mehdi Khosrow-Pour. Copyright © 2003, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

7. IT5622archEvol - Prudential Chamberlain Stiehl: The Evolution of an IT Architecture for a Residential Real Estate Firm,1996-2001; Andy Borchers, Kettering University, USA; Bob Mills, Prudential Chamberlain Stiehl Realtors, USA.

8. IT 5652Telemedecine - Enabling Electronic Medicine at Kiwicare: The Case of Video Conferencing - Adoption for Psychiatry in New Zealand; Nabeel Al Qirim, Consultant, New Zealand.

9. IT5635ERPeCommerceTexas - Management of an E-Commerce-Enabled Enterprise Information System: A Case Study at Texas Instruments; R. P. Sundarraj and Joseph Sarkis, Clark University, USA.

10. IT5699GreeceDSS - A DSS Model that Aligns Business Strategy and Business Structure with Advanced Information Technology: A Case Study; Petros Theodorou, Technological Educational Institution of Kauala, Greece.This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

11. T5697Deutschbank - Deutsche Bank: Leveraging Human Capital with the Knowledge Management System HRBase; Hauke Heier, European Business School, Germany; Hans P. Borgman, Leiden University School of Management, The Netherlands. This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

12. IT5661 – MIShumanWeapons – Human Issues in a Government Management Information Systems Implementation; Susan K. Lippert, Drexel University, USA.This chapter appears in the book, *Annals of Cases on Information Technology* Technology, Volume 5 edited by Mehdi Khosrow-Pour. Copyright © 2003, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

13. IT5674quality/ERP - Business Process Re-Design in Travel Management in a SAP R3 Upgrade Project – A Case Study; Marit Schallart, Queenskand University of Technology, Australia. This chapter appears in the book, *Annals of Cases on Information Technology* Technology, Volume 5 edited by Mehdi Khosrow-Pour. Copyright © 2003, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

14. IT5709 - Improving PC Services at Oshkosh Truck Corporation; Jakob Holden Iversen, Michael A. Eierman, George C. Philip, University of Wisconsin Oshkosh, USA. This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

15. IT5617SchemaInstanceEmol - Long-Term Evolution of a Conceptual Schema at a Life Insurance Company; Lex Wedemeijer, ABP, The Netherlands.

16. IT5724probsGuam - Public Sector Data Management in a Developing Economy; Wai K. Law, University of Guam, Guam.This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

17. IT5704InfosysKM - Towards a Knowledge-Sharing Organization: Some Challenges Faced on the Infosys Journey; V. P. Kochikar Infosys Technologies Limited, India; J. K. Suresh Infosys Technologies Limited, India. This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

18. IT5562UsGovt - Business Reengineering at a Large Government Agency; Nina McGarry, PRC Ince; Tom Beckman, Internal Revenue Service, USA.

19. IT5705PeruLandReg – Technological Modernization of Peru's Public Registries; Antonio Diaz-Andrade, Martín Santana-Ormeño, ESAN, Peru. This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6*, edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited.

The following case studies were considered but did not provide an overall focus on descriptions of technology change and/or information relevant to the 19 categories of information in Tables 2/3. The emphasis of each study is indicated within each study description.

20. IT5503LaurierTea – Laurier IT Priorities - Discussion Paper, Ron Craig, Wilfrid Laurier University, Ontario. This case focused on project managing the wider context within which implementation takes place.

21. IT5507EISevolution - Evolution of an Executive Information System: The Replenishment Data Warehouse at Jeans Wear - Hamid Nemati, University of North Carolina, USA; Keith Smith, VF Corporation, USA. This case has a focus on the organisational context within which IT change takes place.

22. IT5511hongkongThai - Implementation Failure of an Integrated Software Package: A Case Study from the Far East1; Suprateek Sarker and Saonee Sarker, Washington State University, USA. This case focused on managing the wider context within which implementation takes place.

23. IT5563EndUserUS - End-User Computing at BRECI: The Ordeals of a One-person IS Department; Kathleen Moffitt, California State University, Fresno USA. An SME case study about the wider organisation context within which IT is developed.

24. IT5581privacy - An Expectation of Privacy: When Does an Employer Have the Right to Monitor Employee E-Mail Messages?; Andrew Urbaczewski, Washington State University, USA; Juho Rikala MARS, Inc., Finland. A case study about ethics when using email.

25. IT5584ammireal - Corporation: Information Technology and Organizational Performance - Mo Adam Mahmood, Gary J. Mann and Mark Dubrow, University of Texas at El Paso, USA. A case study about the relationship between IT investmant and organisational performance.

26. IT5595VirtualB – Comparative Study of the Usefulness of On-line Technologies in a Global Virtual Business Project Team Environment; Simpson Poon and Shri Rai, Murdoch University, Australia. A case study about the context in use of on-line technologies.

27. IT5595VirtualBTea - Comparative Study of the Usefulness of Online Technologies in a Global Virtual Business Project Team Environment, Discussion Case, Murdoch University, Australia.

28. IT5622archEvol - Prudential Chamberlain Stiehl: The Evolution of an IT Architecture for a Residential Real Estate Firm,1996-2001; Andy Borchers, Kettering University, USA; Bob Mills, Prudential Chamberlain Stiehl Realtors, USA.

29. IT5647Winery - Lone River Winery Company: A Case of Virtual Organization and Electronic Business Strategies in Small and Medium-Sized Firms; Emmanuel O. Tetteh, Edith Cowan University, Australia.

30. IT5682VirtualTeams - System Development by Virtual Project teams: A Comparative Study of four Cases; David Croasdell, Andrea Fox, Suprateek Sarker, Washington State University, USA. A case study comparing four virtual project teams.

31. IT5687SoftwareCoEvolv – Software Vendor's Business Model Dynamics Case: TradeSys; Risto Rajala, Matti Rossi, Virpi Kristiina Tuunainen, Helsinki School of Economics, Finland. This case study concentrates on the evolution of a business model.

32. IT5715AmbulanceMelbourne - Emergency: Implementing an Ambulance Despatch System; Darren Dalcher, Middlesex University, UK This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6,* edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited. The focus of this case study is its highlighting of the pitfalls and implications of failing to consider the financial pressures and resource constraints that define the (medical) despatch environment.

33. IT5716adoptIndia - Challenges in the Adoption of Information Technology at Sunrise Industries1: The Case of an Indian Firm; Monideepa Tarafdar, University of Toledo, USA; Sanjiv D. Vaidya, Indian Institute of Management, Calcutta, India.This chapter appears in the book, *Annals of Cases on Information Technology 2004, Volume 6,* edited by Mehdi Khosrow-Pour. Copyright © 2004, Idea Group Inc. Copying or distributing in print or electronic forms without written permission of Idea Group Inc. is prohibited. A case about the business context when change takes place

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Appendix 4 – Supporting information

Over the period considered (i.e.1992-2010) the central issue has been the continuing illustration of problems in RE. There have been a number of subject categories.

Overarching subjects:

- High-levels of generality - (Harker *et al*., 1993), (Jarke and Pohl, 1994), (Strens and Sugden, 1996), (Nuseibeh and Easterbrook, 2000), (Highsmith and Cockburn, 2001), (Abrahamsson P. *et al*., 2003), (Robertson S. and Robertson J., 2006), (de Wit. J.J. and Ponisio, 2008), (Glazer H. et al., Nov. 2008), (Tanabe et al., 2008), (Davis *et al*., 2008).

Detail RE subjects:

- Change over time and inter-relations - (Franken and Jansen, 1998), (Lam *et al*., 1999), (Nuseibeh and Easterbrook, 2000), (Gross and Yu, 2001), (Mylopoulos. J, 2001), (Castro.J. et al., 2002), (Goldenson *et al*., 2003), (Rolland *et al*., 2004), (Etien and Salinesi, 2005), (Robertson S. and Robertson J., 2006), (de Wit. J.J. and Ponisio, 2008), (Glazer H. *et al*., Nov. 2008), (Mathisen *et al*., 2009), (CAiSE, 2010 - p.1).

Stakeholder engagement subjects:

- Common language - (Harker *et al*., 1993), (Cockburn, 1997), (Harker and Eason, 1999), (Gall and Berenback, 2006), (de Lima *et al*., 2010).
- Early stage - (Jarke and Pohl, 1994), (Harker and Eason, 1999), (Strens and Sugden, 1996), (Nuseibeh and Easterbrook, 2000), (Mylopoulos. J, 2001), (Jackson, 2001) , (Robertson S. and Robertson J., 2006), (Mathisen *et al*., 2009), (CAiSE, 2010).

Pattern subjects

- (Wellman, 1992), (Vlissides *et al*., 1996), (Gardner *et al*., 1998), (Nuseibeh and Easterbrook, 2000), (Highsmith and Cockburn, 2001), (Gross and Yu, 2001), (Mylopoulos. J, 2001), (Jackson, 2001), (Kavakli, 2002), (Abrahamsson P. *et al*., 2003), (Robertson S. and Robertson J., 2006), (Castro.J. *et al*., 2002), (BPMDS, 2010).

Problem analysis subjects

(Jackson, 2000)**,** (Bleistein *et al*., 2004), (Hall and Rapanotti, 2004), (Etien and Salinesi, 2005), (Robertson S. and Robertson J., 2006) (Mathisen *et al*., 2009).

These recurring subjects represent problem contexts from the past. Identifying recurring problem contexts suggests they should be considered when reasoning about problem contexts in the present. Recurring problem contexts can provide a source of reference and potential guidance when deliberating about the RE context in the present.

Overall, the central issue in chapter 2 has been the continuing illustration of problems in RE and a consequent need for a problem approach focused on the analysis of context. Whilst there have been problems unique to particular times, the need for context analysis has been emphasised by the identification of recurring problems throughout the period.

AP 4.1 – Notes on grounding descriptions

When scoping and describing problem context Jackson's suggests that:

''…you are relying on the domain properties to bridge the gap between the specification phenomena that the machine can directly sense and cause and the requirement phenomena that your customer is interested in….''… that is why it is important to bring the domains and the requirement together…''(Jackson, 2001- p. 56).

When applying Jackson's approach to scoping descriptions we add guidance from Robertson and Robertson's codification of requirements analysis in the organisation context. They separate the technology, referred to as *product*, from the business process, referred to as *'the work*'

''…the significant task of the requirements analysis is to determine what the work should be in the future and how the product can best contribute to that work…''(Robertson and Robertson, 2006 - p. 29).

Robertson and Robertson identify the importance of locating the true origin of *business event.*

''…Business events happen in the adjacent systems- usually the event is a demand for a service provided by the work…''(Robertson and Robertson, 2006 - p. 68).

Locating the origin of the *business event* provides a grounding that facilitates analysis of what can or should not be automated and what problems might emerge. The relationship between a *demand for service* and *existing work* may be under-scoped if the *business event* is not identified. For the wider organisation environment Robertson and Robertson refer to the relationship of 'the work' to the outside world (Robertson and Robertson, 2006 - p. 70). You have to know how the business activity of your client/customer relates to the world outside it. These consist of automated systems, people, departments, organisations and other parties who place some kind of demand or make some kind of contribution to the work.

For the general *macro* environment within which the organisation exists we refer to marketplace developments influenced by political, economic, social and technological change (Stacey, 2003).

Our guidance on locating and grounding problem illustrates the representation of Jackson's generalisation that:

''…The problem is not at the computer interface – it is deeper into the world, further away from the computer…'' (Jackson, 2001 - p. 7).

There are further references from the literature that provide continuing support and understanding when applying the framework.

In the 1990's Harker *et al.,* advised there can be a need for alternative domain descriptions.

''…one important implication of the subjectivity of requirements is that there can be multiple views of requirements, which arise from different settings within the client organisation…'' (Harker *et al.*, 1993 - p. 267).

Jackson suggests variations in domain characteristics can effect development descriptions, the choice of language for each description and the argument necessary to address each problem frame's concern. In his problem frame approach he advises that within a frame's restrictions there is still scope for variations in domain characteristics. The scope of each description is a set of phenomena of the domain; for each description you must consider the domains characteristics as they appear filtered through the lens of that scope. So when referring to domain flavors, you are always talking about the flavors seen from the point of view of a particular description with a particular scope. He states:

''… In short, you will probably need to make several descriptions of each domain in your development…'' (Jackson, 2001 - p. 32).

Robertson and Robertson refer to different user descriptions when building abstract models of the work structure. Models should reflect the work as all users see it rather than as one user sees it. They also note that techniques for requirement elicitation have limits that can restrict the information abstracted. For instance interviewing users may work well for conscious

requirements but few people know all their requirements (Robertson and Robertson 2006 - p.104).

We are guided by Jackson's approach to uncertainty for the 'nitty gritty' process of abstracting descriptions. First, he states that:

''*…There is a circular relationship between the problem and its context…so in practice you must work iteratively. You include a particular domain …that leads you to realise that there is an aspect of the problem requirement that you hadn't considered, reconsidering the problem requirement leads you to recognise there is another domain to take into account….and so on…*'' (Jackson, 2001 - p. 24).

Jackson's approach to problems (Jackson 2001) provides continuing support and we abstract the following elements as examples of what we draw on to characterise the differentiation between problem context and solution.

- *Domain* – a set of related phenomena that are usefully treated as a unit in problem analysis and represented as a unit in a problem diagram. All the domain descriptions in a problem context (i.e., in our case organisation domain, problem domains and their interfaces) are indicative, *they assume the technology is in operation* (Jackson, 2001- p. 22) and show the problem world as it will be when the technology is in operation. All the domains are physical (i.e., represent the parts of the world the customer can check for observable effects) and they include *given domains* which you are not free to design, and *design domains*, a physical realisation of a description or model that the developer is free to design. (Jackson, 2001- p. 21).
- *Control characteristics* – the characteristics of a domain pertaining to the control of its phenomena, for example, whether it is active.

- *Structural characteristics* – the characteristics of a domain concerned with the structure of its relationship phenomena (i.e., pattern or structure among the phenomena of a domain).
- *References* - a connection between a requirement and a domain or between a description domain and another domain: the connection consists of references to phenomenon of the domain.
- *Phenomena* – an element of what we can observe in the world. When considering shared phenomena (Jackson, 2001- pp. 34-5) there are two questions you need to consider. What is shared between the connected domains and which of the sharing domains control the occurrence of events, or the changes in states, or the determination of the values (noting these sharing's are abstractions in which a lot of messy detail has been ignored). As an abstraction it is ignoring irrelevant material for the purpose in hand, or representing an instantaneous event.
- *Interface* – a connection among two or more domains consisting of phenomena that they all share. Interfaces, like domains are physical and direct. It is not to be thought of as a stream of messages flowing between the domains. Instead we think of events states and values as being shared between the connected domains. Each interface is an interface of shared phenomena (i.e., the participation in a shared event is like a hammer hitting a nail, there is only one event).

AP 4.2 – Chapter 5 – Generic organisation change frame and variants

The following information supplements stage 4 data in chapter 5. It describes the additions made to the level of generality in the conceptual framework. These additions refer to Tables 5 and 6 which replicate the tables in chapter 3 (Stage 1 data). They are included to avoid readers having to refer to chapter 3.

Stage 4 data.

The level of generality expressed in chapter 5.2 (Real-world studies and organisation patterns) extends that used in the conceptual framework by the addition of the following structures and descriptions abstracted from case studies.

1. Two domains are added to Organisation Socio-technical (macro) referred to as Provider (non-IT) and Connectivity. The Provider (non-IT) domain represents the non-IT service in the organisation. The Connectivity domain provides an IT connection between Organisation Socio-technical (macro) and Environment (organisation-wide).

   These additions reflect identification in all 19 real-world studies of technology used in communications and, associated descriptions of non-IT activity when providing a technology driven service.

   Relevant data example - columns F/N/O/Q

2. The description Subject Category (IT) is added to the Organisation Socio-technical (micro) description. Each of the 19 real-world studies identified the subject of its technology change.

   Relevant data example - columns A/B/P

3. Three domains identified as Existing IT, IT Operator and Change IT are added.

   These three descriptions represent the occurrence in each case study of reference to existing IT, employees operating IT and change IT. In the case studies they provided a general reference for scoping the detailed micro context in which change takes place.

   Relevant data example - columns A-S

4. Intra, Inter and Extra Organisation descriptions are added to the Environment domain. They are described as:

- Intra-organisation - refers to those activities managed by the organisation and incorporates employees, subsidiaries, etc.

- Inter-organisation - refers to working with other companies connected with the organisation's regular activities and includes suppliers, subcontractors, etc.

- Extra-organisation - represents the wider environment that impacts on organisation activities and includes customers, consultants, competitors, etc.

In the conceptual framework, *Environment* represented both the macro environment (i.e., those parts having a deterministic influence on organisation, e.g., political, economic, social, legislation) and the micro environment (i.e., those parts of environment the organisation can influence in a deterministic way, e.g., customers). These three descriptions are added to facilitate the identification of more detailed domain knowledge of micro environment. The context each represents was referred to in all case studies, individually or in some form of combination.

Relevant data example - columns A/C/I/L

Table 5 (copy of Table 2) 1-10 (Stage 1 data)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	Subject of change + Town/City/ Local/Agency Region/ National	**Add, remove replace technology**	**Org wide and/or subsidiary**	**Quality, Cost, Delivery**	**Country**	**change reason+ Enabler,Lever, Foundation**	**change type**	**Level of change**	**scale of change**	**Subject area**	**Time Scale**	**level of granularity**	**Aspect of Case Study used**	**Business Process**	**Business Services**	**Technology described**	**alignment?**	**Knowledge Management**	**Evolution evident**
C.S.1	**Implementing workflow management software** - national public company	**REPLACE** Historic changes described-potential tracking etc- plus KM	Org wide	Quality improvement re: workflow process	Germany	upgrading workflow management- **ELF Processes**	operational-software upgrading-reengineering	sw-operational	publicly quoted company-detailed workflow described	media company	1990-2000	operational detailed-ie:workflow	Live project	improve process automation-integrated archiving solutions-managing		SAP R/3 plus IXOS ARCHIVE (Knowledge repository)	Business document management system with workflow solution	IXOS = knowledsge repository of org memory re: org. knowledge distribution	Yes
C.S.2	**Electronic Workflow implementing EDI** - Gov.Agency	**ADD** evolutionary changes described	organisation wide	QCD page 1	USA	Increased competition - using IT to improve business process **ELF=Process**	operational software-EDI	sw - operational	National company, detailed workflow described	National Laboratory for Government Projects	1995-2003	operational detail (workflow)	Live project	process automation		evolution systems described	elecronic workflow		Yes
C.S.3	**Network Implementation-** Development Agency - tourism, food, manufacture	**REPLACE**	Office system	Quality - p4	Scotland	IT to improve service quality **ELF-Network**	HW/SW-operational	HW/SW-operational	Local Area Office	Government Business Agency		Internal-ext. network	Live Project	network automation	improve service quality	layout of network - no spec	Agencys with Head Office	by implication	No
C.S.4	**Provision of electronic delivery/analysis of financial data.** A 3.5billion subsidiary of a private company	**REPLACE**	subsidiary relationship with owner company	Quality re: improving BtoB services within the organisation p488	North America	Head Office requires a common platform for its subsidiaries- **ELF processes**	SW-operational	HW/SW operational	Divisional Office (6 divisions)	Integrating finances of 6 divisions exampled by one division	2002	sw spec	Live project	Improving BtoB service within the organisation		Description - eg SAP ERP but no spec.	alignment of evaluation and delivery of financial info with dissemination to 6 divisions (ie: process improvement)	by implication	No
C.S.5	**Electronic improvement of audit capability-** Benefits Office of an International Union	**ADD +** evolution potential	subsidiary	IT enhancing operations-p9	USA	CEO believes IT can enhance operations- **ELF Network (internal)**	SW/HW	operational-workflow	subsidiary	IT -mini computer system for benefit services	1979-1998	sw description- no spec.	Live project	enhancing operations	provision of benefits-audit capability	description plus some evolutionary spec	New IT with business process	by implication	Yes - 1979-1998
C.S.6	**Electronic support for a TQM model**-a subsidiary with IT management responsibility for a large Corporation	**ADD +** evolution potential	subsidiary	IT support for a TQM programme + use of Balanced Scorecard	Peru	IT support for the TQM model **ELF Network (internal)**	sw	operational workflow	Corporate IT application to 2000 subsidiaries	Implementing QD Monitor (sw) incorporating the Balanced Scorecard	1979-2000	sw descriptions and some spec.	Live Project	IT evidence that the improvement strategy is under control	Btob support (internal)	described with some spec.	IT support for business process	Continuous Quality Improvement Programme	Yes - 1979-2000
C.S.7	**Prov. of electronic network (WAN/LAN),real estate firm,**14 offices	**ADD** + evolution potential	org. wide	QCD page 13	USA	Implmenting WAN/LAN- **ELF Network**	sw/hw	operational networking-employees	org application to 14 offices	wan/lan network	1996-2001	sw descriptions and some spec.	Live project	linking offices to enhance connectivity	btob internal support-employees sharing knowledge	configuration described with some spec.	network support for business process	network providing sharing of knowledge	yes-1996-2001
C.S.8	**Vid/conference telemedicine-customer/patient hospital contact**	**ADD**	organisation wide	by implication	New Zealand	improving remote service- **ELF-process**	sw/hw	operational - service	hospital to patient contact	providing remote patient access	1993-1996	process description	Live project	provision of remote patient access	provision of remote patient access	description	IT driven business process/business service	by implication-provision of!	No
C.S.9	**Implementing internal / external Enterprise Resource Planning (ERP)**	**REPLACE**	organisation wide	competitive advantage - p2	USA-global company	improving employee, customer, supplier linkage process- **ELF process / network**	sw/hw	strategic/ operation application	global cross organisation, employee, customer, supplier	ERP implementation in a global setting (process)	1996-2000	process description-	Live project	employee, supplier, customer contact	internal btob support	description	employee, supplier, customer	competitive advantage -p2	yes
C.S.10	**Technology implementation to align business strategy and structure** - food industry	**ADD**	organisation wide	QCD-p159	Greece	an integrated system increasing flexibility in managing enterprise resources-**ELF process / network**	sw/hw	strategic/ operation application	internal and supply chain	additional sw applications	1999+3 - 5 yr. planning	strategic intent, operational applications	Live project	process-additional sw content	support for….BS	description	comprehensive info. p158	throughout-eg:p156/159 etc	yes

Table 6 (copy of Table 3) 11-19 (Stage 1 data)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	Subject of change + Town/City/ Local/Agency Region/ National	**Add,remove replace + evolution potential**	**Org wide and/or subsidiary**	**Quality, Cost, Delivery**	**Country**	**changereason+ Enabler,Lever, Foundation**	**change type**	**Level of change**	**scale of change**	**Subject area**	**Time Scale**	**level of granularity**	**Aspect of Case Study used**	**Business Process**	**Business Services**	**Technology described**	**alignment?**	**Knowledge Management**	**Evolution evident**
C.S.11	**Internet/ intranet based e-business applications**-German Bank	**ADD**	organisation wide	KM and comp. advantage throughout	Germany	internet based e-business applications **ELF process/ network**	sw/hw	strategic / operational application	global rollout to customers and new markets	internet based business applications	1999-2001	process description	Live Project	contacting customers and new markets globally	support for….BS	system analysis, design, programming, testing,rollout	IT to needs and opportunities	Fundamental-p1	Yes
C.S.12	**Integrated MIS system -** Govmnt. agency	**ADD OR REPLACE**	org wide	quality of process through automation	USA	automating the integration of product and functional processes-**ELF process**	sw/hw	operational	organisation wide	integrating MIS	mid 1990's-spanning 10 years (p123)	strategic and process description	Live project	integrating process	improving support	components and processes described	automated configuration to align acquisition / procurement process	by implication	Yes
C.S.13	**SAP R/3 upgrade** - Corporate Services Govmnt. Agency	**REPLACE**	org wide	process emphasis on cost-travel expense management	Australia	integration of information systems - **ELF process**	HW/SW-operational	operational	organisation wide	travel expense management	1996-2002	strategic intent-operational activity	Live project-travel management	integrating IT process-process management life cycle - p322	managing costs	description - some spec.	IT	KM through improved process	Yes
C.S.14	**Head office / Group call centre IT integration -** International Truck business	**REPLACE INTERMEDIARY**	Group wide	process emphasis	USA	integrating call centre IT activities - **ELF process**	hw/sw	strategic / operational application	group wide	call centre handling of user problems	2000-2003	strategic intent - operational activity	Live project	IT process improving user satisfaction/ productivity	user satisfaction	description plus sme spec.	IT call centre activity	KM through improved process	yes
C.S.15	**Concept: link between info req. and perceptions of reality -** a life insurance company	**ADD**	Group wide	Quality of flexibility - p4	Netherlands	Quality of conceptual schema for flexibility and change - **ELF process**	sw	operational	org. wide	integrated benefit admin info system	1996-1999	strategic intent - operational activity	Live project	process IT info system	Benefit admin IT info system	description plus some spec.	CS providing linking between req and perceptions of reality	KM through IT process development	yes
C.S.16	**IT for Import and Export info Reports** at a Govnmt Agency	**ADD INTERMEDIARY**	Agency wide	Quality information	Guam	converting process to IT - **ELF-process**	sw/hw	operational	org wide	export / import reports	80's 90's	strategic intent - operational activity	Live project	import / export reports using IT	using data/a resource for economic development	descriptions	IT and business process	by implication	yes
C.S.17	**IT for Knowledge Management** - International Organisation	**ADD**	organisation wide	Quality - p 246	India	multiple process improvements - **ELS process**	sw/hw	operational	org wide	additional IT content/centrali sed and de-centralised functions	1992-2002	strategic intent - op. activity	Live Project	additional IT content/centra lised and de-centralised functions	a KM strategy-a content, people, technology, process	descriptions	KM linking IT with business objectives	Yes	Yes
C.S.18	**Business Reengineering** - Large Govnmt. Agency	**REPLACE** - legacy changes described-potential tracking etc	theoretical example-organisation wide	quality through critical measures of performance and customer value - p11	USA	Reengineering-business processes-**ELF=Processes**	operational -9 software programmes +system actions-mainly proj man people emphasis	SW-operational	Head Office and USA wide Field Offices	Delivery of employee benefits (eg: health)	12 weeks	operational detailed-ie: system actions-technology described-no specs	Hammer (1993) and Davenport (1993) example of ideal in case study	reengineered 9 business processes	internal btob support	comprehensive descriptions and system actions	IT and business process	by implication	Yes
CS 19	**Networking regional offices** - Govnmt. Organisation	**ADD** - org wide ex including reg. offices	organisation wide	re:process - p260	Peru	Networking for customer - employee benefit-reengineering-**ELF Networks**	WAN for 13 regional offices linking clients to the ST system-potential tracking example with multiple changes	HW/SW-operational	Countrywide 13 regional offices linked to head office	Public Registry modernisation	1994-2002	operational-local offices linked to head office-technology described spec.	including historic changes with the focus on the WAN	head office networked to countrywide offices	internal btob support	descriptions and spec.	IT and business processes	by implication	yes

AP 4.3 - Chapter 5 - Diagrams

The following diagrams provide the opportunity to compare the change frame and its variants in supplementing the section 5.3.1.

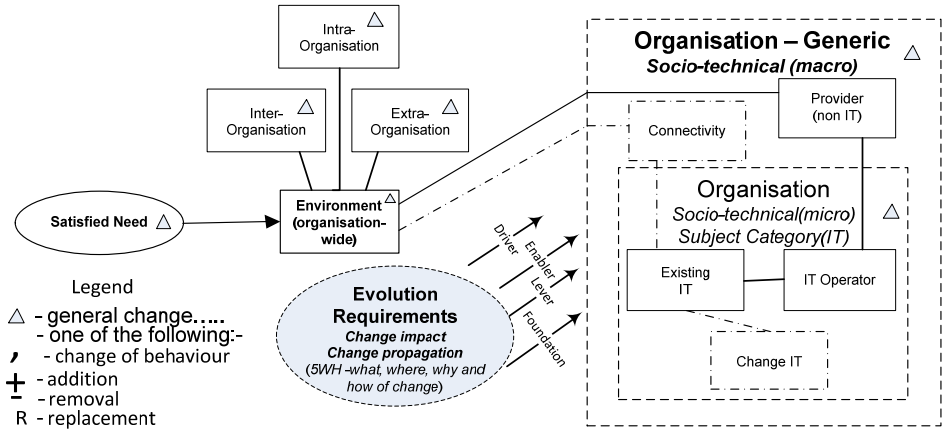

Figure AP 4.3a - Generic organisation change frame

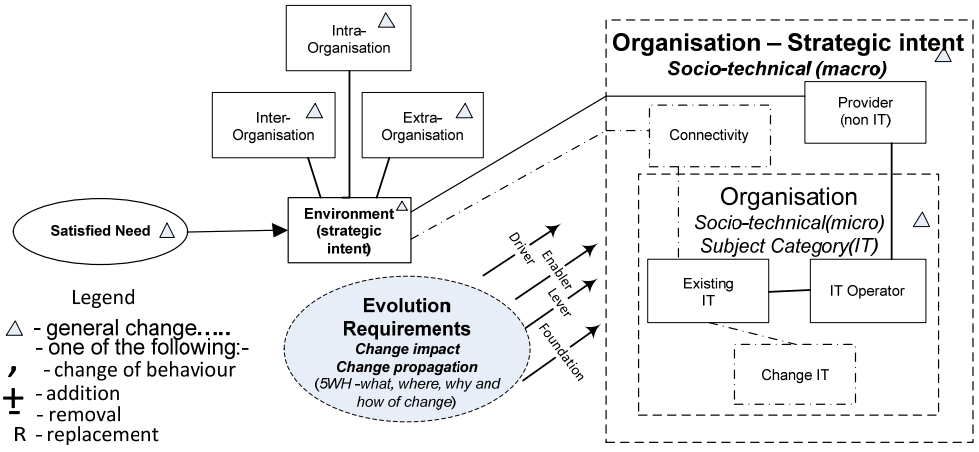

Figure AP 4.3b - Strategic intent variant

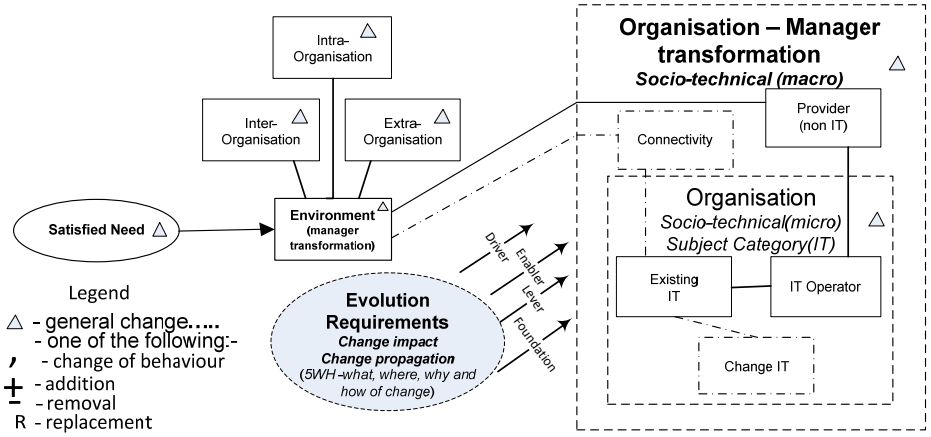

Figure AP 4.3c - Manager transformation variant

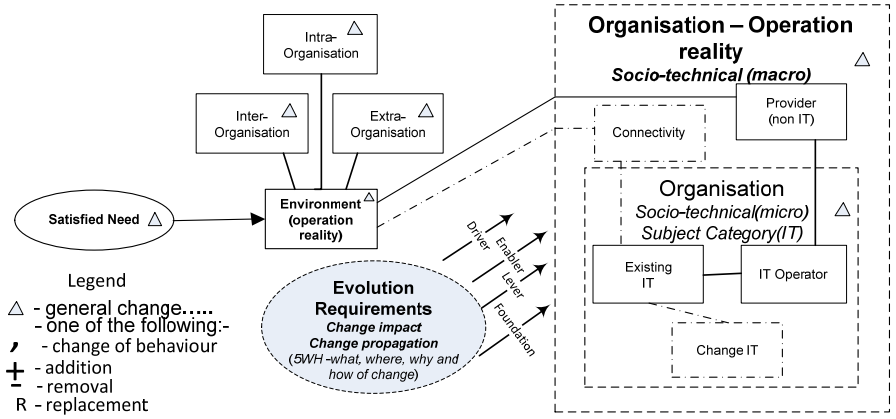

Figure AP 4.3d - Operation reality variant

AP 4.4 - Chapter 6 – Diagrams

The figures in this section refer to the text and supplement the figures in 6.5 and 6.6. They provide an opportunity for comparisons to be made between variants of after-the-change and change impact descriptions.

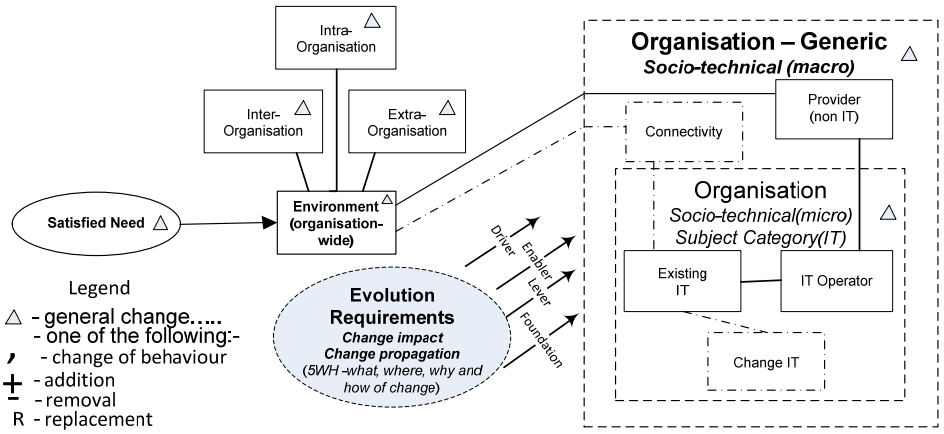

Figure AP 4.4a - Generic organisation change frame

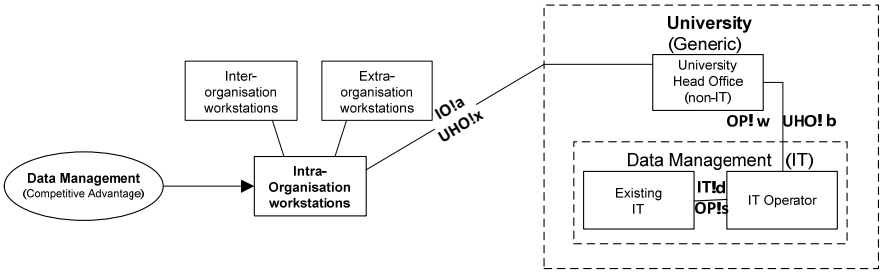

Figure AP 4.4b - University – organisation – wide before-the-change

University - Strategic Intent Variant

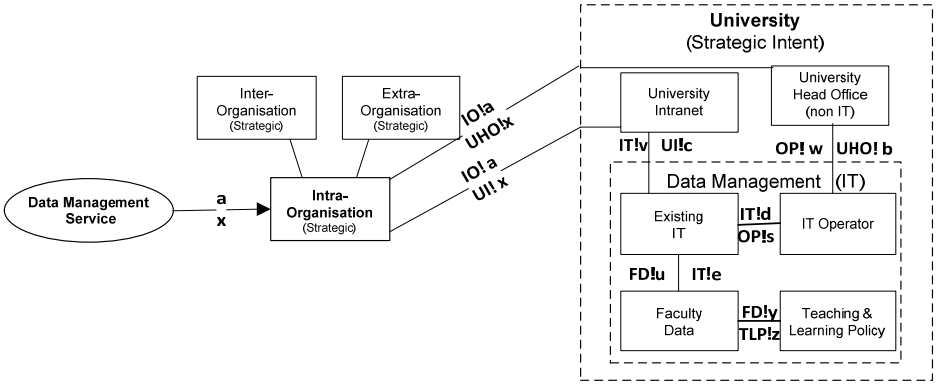

Figure AP 4.4c - Strategic intent - after-the-change

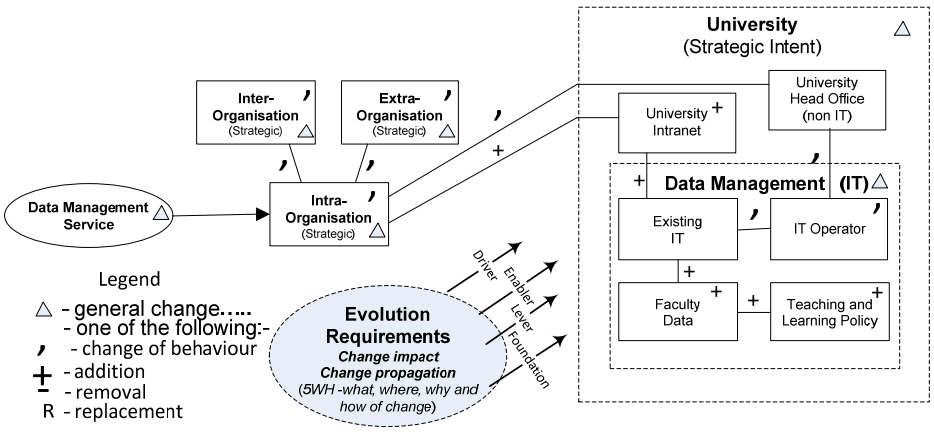

Figure AP 4.4d - Strategic intent - change impact

University - Manager Transformation Variant

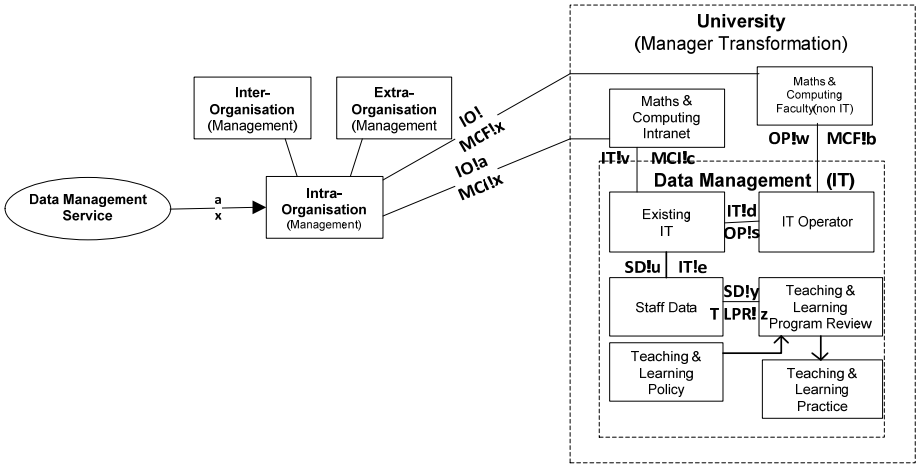

Figure AP 4.4 e – Manager transformation - after-the-change

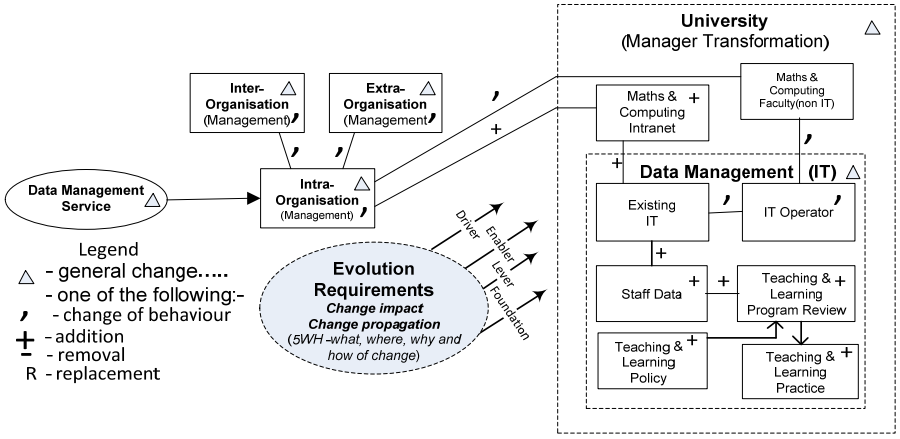

Figure AP 4.4f - Manager transformation - change impact

University - Operation Reality Variant

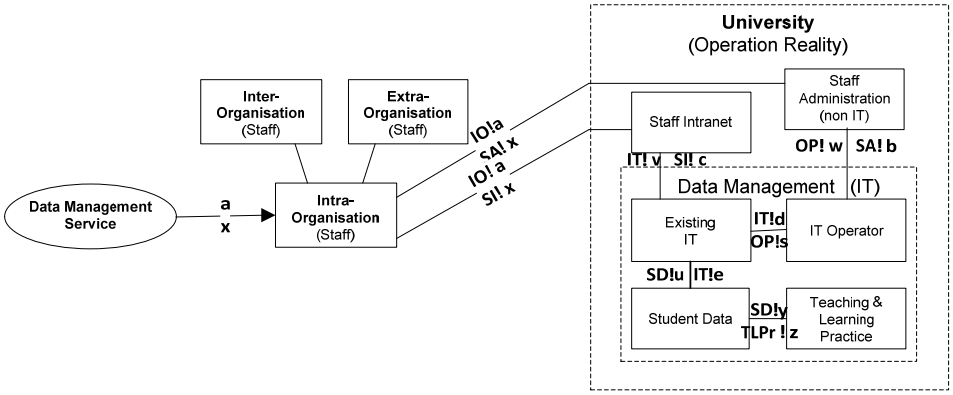

Figure AP 4.4g - Operation reality - after-the-change

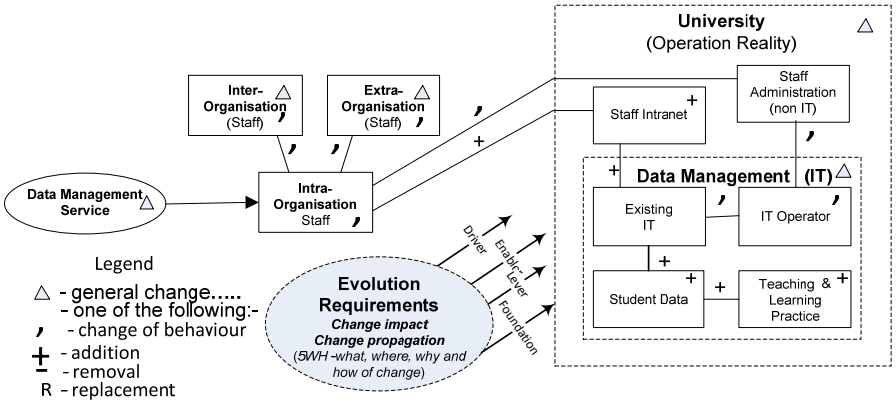

Figure AP 4.4h - Operation reality - change impact

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